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THE
POPULAR SCIENCE
MONTHLY

MAY, 1911

THE FORMATION OF NORTH AMERICAN NATURAL BRIDGES

By Professor HERDMAN F. CLELAND
WILLIAMS COLLEGE

ALTHOUGH there are more than fifty natural bridges of considerable size in North America, comparatively few persons have ever seen one, the reason being that, with the exception of the Virginia bridge and the natural bridge in North Adams, Mass., most of them are more or less inaccessible.

A bridge, according to the usual definition, is a structure that permits one to pass from one side of a depression to another, whether that depression be a railroad cut, a street or a river. As used in this article a natural bridge is *a natural stone arch that spans a valley made by running water;* a natural arch being a structure that does not span a valley of erosion.

Although a number of descriptive articles on natural bridges have

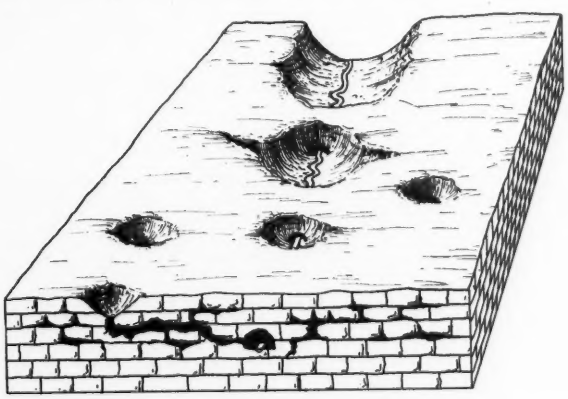

Fig. 1. Block Diagram illustrating the Formation of a Natural Bridge in Limestone by the Partial Caving in of the Roofs of Tunnels.

appeared in recent years, the explanation of their origin has, for the most part, been omitted or has been unsatisfactorily given. In this paper an effort is made to show how the more important North American natural bridges were formed.[1]

In the older geologies and geographies we were taught that all natural bridges were formed in one and the same way. According to this time-honored theory natural bridges resulted from the partial caving in of the roof of an underground tunnel or cavern, the portion of the roof left spanning the chasm being a natural bridge. That natural bridges must occasionally be formed in this way is evident. For example, in Edmonson County, Kentucky, where the Mammoth Cave is situated, it is estimated that there are 100,000 miles of underground passages. In the course of time these passages will be widened and the rocks above them will be worn down by surface erosion until, at length, the roofs will almost completely disappear, leaving portions standing here and there as natural bridges. What is happening in Kentucky now has been going on for countless ages in limestone regions in other parts of the world with the possible formation (Fig. 1) and later destruction of natural bridges. It is a rather curious fact, however, that although many small natural bridges have this history, as, for example, a number of bridges in Florida, Iowa, Missouri and other states, yet, as far as known at present, none of the world's great natural bridges has this origin.

FIG. 2. THE NORTH ADAMS, MASS., NATURAL BRIDGE.

The Virginia natural bridge may be taken as a type of natural bridge formed by solution aided by cracks (joints). This can best be explained by a theoretical case. Let us suppose that a short distance—100 or 200 feet—above the brink of Niagara Falls the water of the river should find a crack athwart its course in the limestone bed of the river and that the water seeping through this crack should flow along the top of a lower layer, and reappear underneath the fall as a

[1] For a more complete discussion see "North American Natural Bridges, with a Discussion of their Origin," *Bulletin of the Geographical Society*, Vol. 21, pp. 313–338, July, 1910.

spring. In the course of years this underground water might eat out a channel which, in time, might accommodate a small portion of the volume of the river. This might eventually be enlarged to such an extent that all the water of the river would pass under the old bed of the river at the fall, leaving the present brink dry land; in other words forming a natural bridge under which the river would flow. The conditions above described have never been fulfilled in the case of the Niagara River and probably never will be, but they were completed in the formation of the Virginia natural bridge, and a bridge of this sort is actually in the process of formation in Two Medicine River, Montana. The height of a bridge of this origin will depend both upon the height of the original fall and upon the amount the stream deepens its valley after the formation of the bridge. The Virginia natural bridge is more than 200 feet high, but the original fall was probably less than that, since the stream has cut down its bed to some extent subsequent to the formation of the bridge.

Within the city limits of the manufacturing city of North Adams, situated in a valley which is beautiful in spite of the efforts of man to render it unsightly, is a natural bridge which well repays a visit. It is one of the most picturesque of natural bridges (Fig. 2) composed, as it is, of white marble with nearly vertical walls. It is small as natural bridges go, the top being but 44 feet above the stream bed and the cavity beneath only about 10 feet wide and 25 feet long. This bridge was formed somewhat as the one just described but differs in some important particulars.

Across the Kicking Horse River in the Canadian Rockies, a short distance from Field, B. C., amid some of the grandest scenery on the continent, within sight of primitive forests and glaciers, is a curious natural bridge and one which, at first sight, does not fulfill our conception of such a structure. In this case the opening is almost too small for the volume of the river, so that during floods the water probably flows over the top. The path which one follows in crossing the bridge is almost a horizontal S (see Fig. 3). This bridge was formed largely by "pot-hole" action. Almost everyone in New England has seen those interesting round holes which have been formed in the beds of swift streams by the whirling of pebbles in a permanent eddy until, after many years, a hole is bored which may be several feet in diameter and many feet deep. In the Kicking Horse River there was formerly a rapid or fall on which pot-holes were developed. These holes deepened and broadened at their bottoms until at length (Fig. 4) the walls of two of them were worn through near their bases and permitted the water of the river to flow through the opening thus made. In other words, the natural bridge across the Kicking Horse River is the sides of which were worn through so that the holes opened into one another.

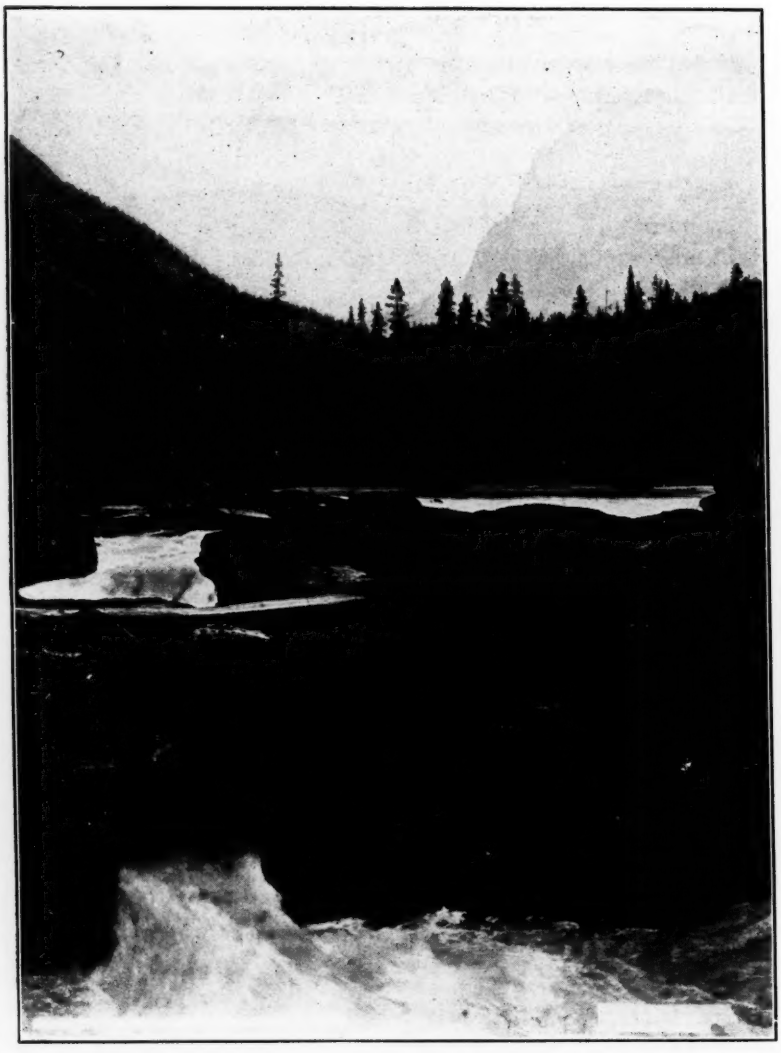

FIG. 3. THE NATURAL BRIDGE ACROSS THE KICKING HORSE RIVER NEAR FIELD, B. C.
Formed by "pot-hole" action.

There are probably many small streams that are spanned by bridges of this sort, but few of them have been reported. Two such occur in Vermont.

In Kentucky are several arches with an unusual origin which should perhaps be included under the term natural bridge. They were formed in a plateau composed of horizontal sandstone and limestone by the cutting back of the heads of two streams flowing in opposite directions in deep valleys. The streams continued to cut back until only a narrow ridge or divide separated their basins. This divide was in time perforated by the action of water, wind and frost until at length a fine bridge resulted. One of these (Fig. 5) near the station of Natural Bridge on the Lexington and Eastern Railroad, is 32 feet high and 66 feet wide. There are three bridges, or arches, of this origin within a radius of three or four miles.

In narrow mountain valleys natural bridges are sometimes formed by a large rock falling down the mountainside and wedging into the valley. In Switzerland two bridges of this sort are actually in use by pedestrians, but none has been reported in this country, though many doubtless exist. An unusual bridge formed by gravity (Fig. 6) is one consisting of a large slab which was separated from one side of a valley and fell to the other side. When the crack was filled with débris a usable bridge resulted.

In the Yellowstone National Park a natural bridge (Fig. 7) composed of a lava made up of vertical plates of compact and porous rock spans Bridge Creek near Yellowstone Lake. The bridge, although only forty feet high, is very interesting, both because of its rugged beauty and of its unique origin. An examination shows that the bridge is made of two vertical slabs of lava, one two feet and the other four feet thick, separated by an opening two feet wide. The bridge was formed as fol-

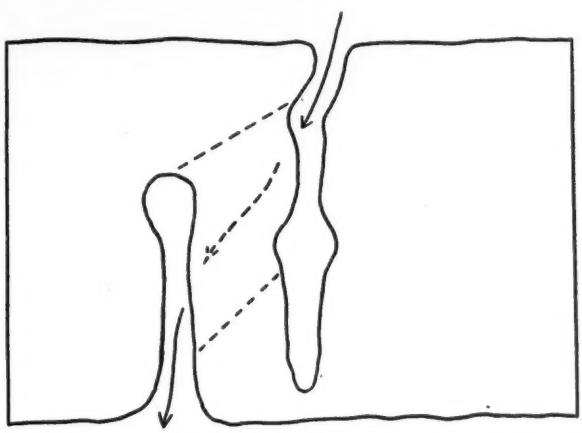

FIG. 4. DIAGRAM SHOWING THE COURSE OF THE KICKING HORSE RIVER UNDER THE BRIDGE. (See Fig. 3.)

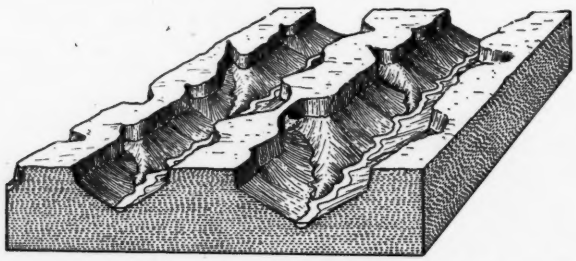

FIG. 5. A NATURAL BRIDGE NEAR THE STATION, NATURAL BRIDGE, KENTUCKY.

lows: at one time the stream flowed over a fall which is now represented by the top of the bridge; in the course of time the freezing of the water between the thin vertical plates of which the slabs are composed at the foot of the fall forced them apart, making it easy for the water from the fall to wear away the rock at its foot and to excavate a cave. This cavity was gradually extended up stream until a porous layer was encountered through which the water of the stream poured into the cavity, thus forming a bridge of the first of the two slabs. The same process was continued with the undercutting of the second slab. In this way a natural bridge was formed. It is hardly probable that another structure made in the same way is in existence.

It does not seem possible at first thought that a natural bridge more than 125 feet high could be formed by the deposit of lime from water (travertine), but such a bridge (Fig. 8) occurs near the little Mormon

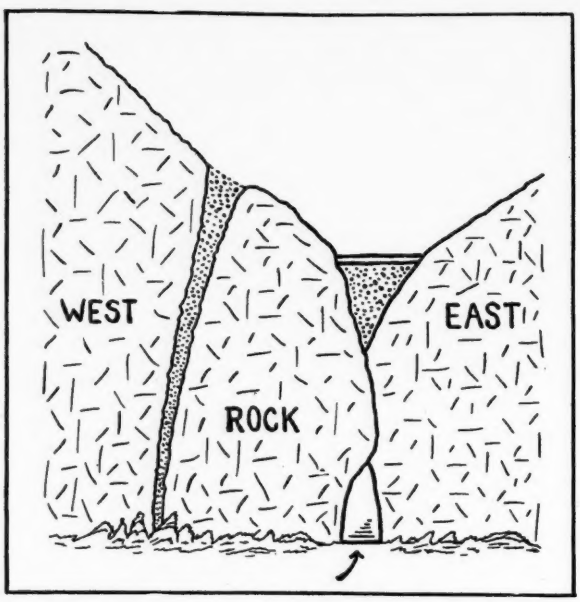

FIG. 6. BLOCK DIAGRAM TO SHOW A BRIDGE FORMED BY THE HEADWARD CUTTING OF TWO STREAMS IN A PLATEAU REGION.

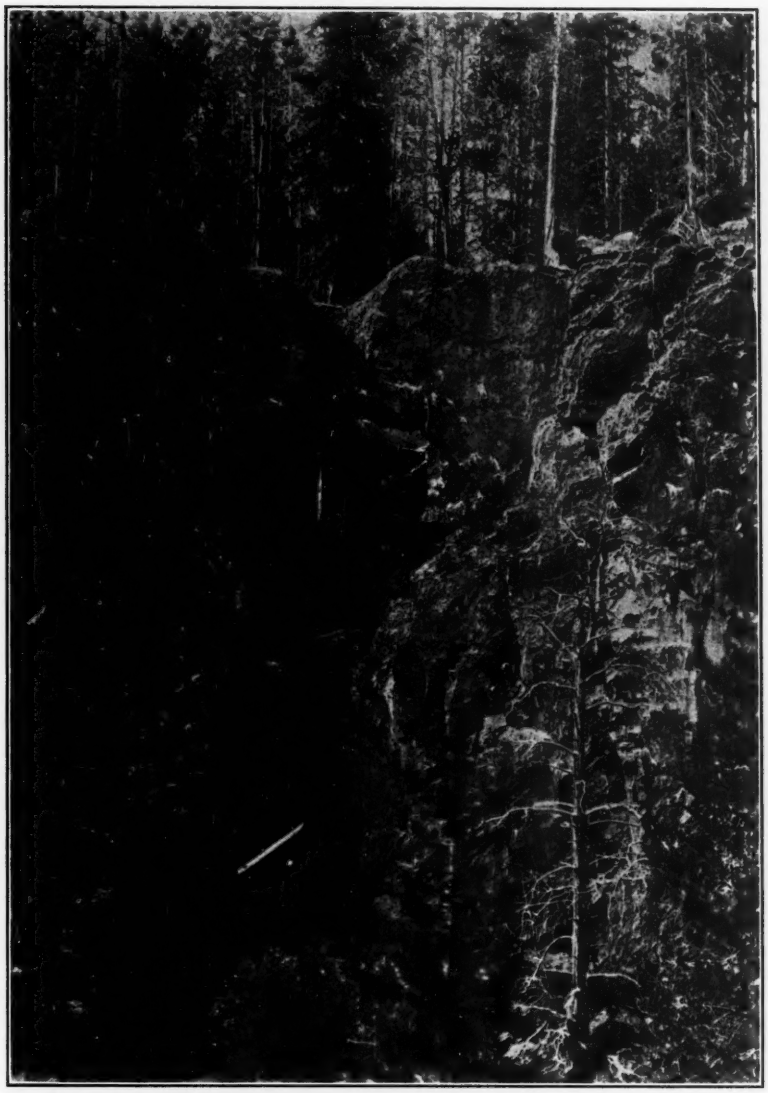

FIG. 7. THE LAVA NATURAL BRIDGE ACROSS BRIDGE CREEK, YELLOWSTONE NATIONAL PARK.
Simply that portion of the rock of the former fall between two pot-holes.

village of Pine about 90 miles south of Flagstaff in Arizona, and can be reached by a horseback journey of three days from that city. As one travels south from Flagstaff through the forest reservation he passes for miles over a lava plateau which, were it not for the pines and cedars, would be called a desert. The forest does not fulfill the usual conception of a wooded region since the trees, though gigantic, are far apart and underbrush is entirely absent. After many hours of travel over a

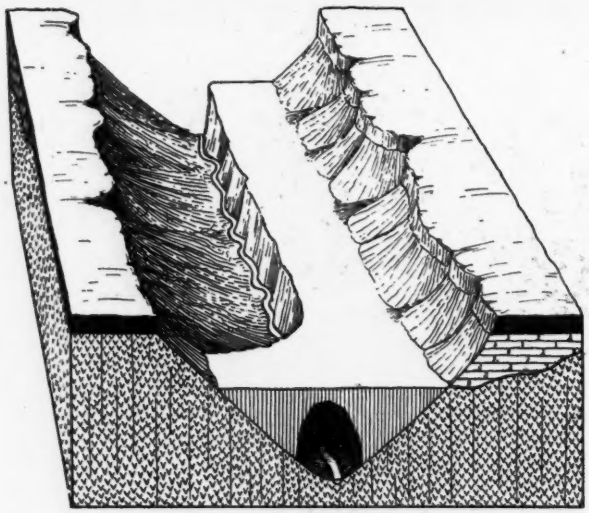

FIG. 8. BLOCK DIAGRAM TO SHOW THE FORMATION OF THE TRAVERTINE NATURAL BRIDGE AT PINE, ARIZONA. This bridge was formed by the deposits of travertine derived from the springs on the east. (In the diagram the height of the bridge is exaggerated.)

country of this sort, the brilliant green of the irrigated valley of which the natural bridge is a part seems remarkably beautiful and is a sight not soon forgotten. Not only is the bridge composed of this limestone

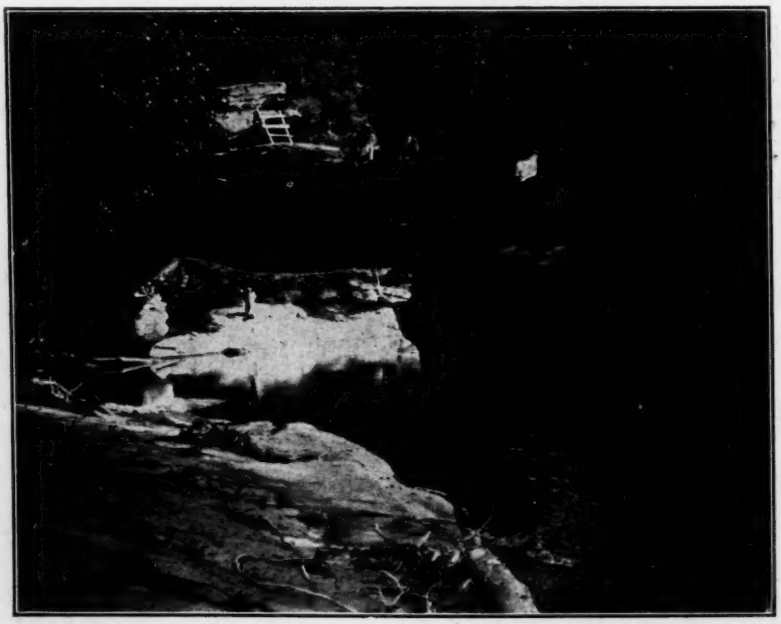

FIG. 9. TWO VIEWS OF THE NATURAL BRIDGE ACROSS SWIFT'S CAMP CREEK, NEAR CAMPTON, KENTUCKY. (See Fig. 10.)

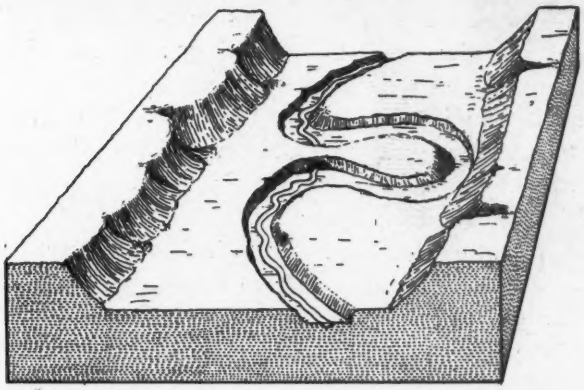

FIG. 10. BLOCK DIAGRAM TO SHOW THE FORMATION OF A NATURAL BRIDGE BY THE PERFORATION OF AN ENTRENCHED MEANDER. (See Fig. 9.)

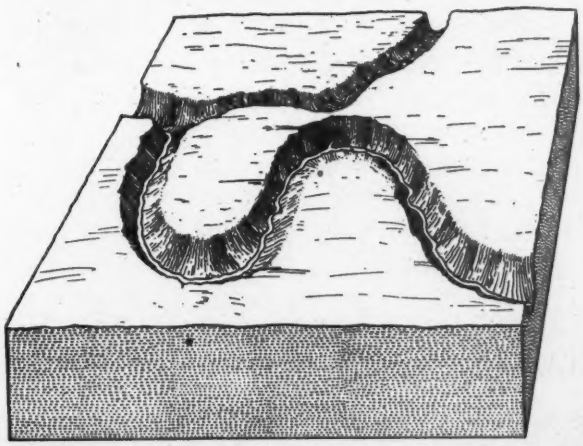

FIG. 11. BLOCK DIAGRAM TO SHOW A BRIDGE FORMED BY THE TUNNELING AT A MEANDER BEND OF A NARROW DIVIDE BETWEEN THE MAIN AND TRIBUTARY STREAM.

deposit (travertine) but also the whole of the cultivated valley of about 25 acres. The bridge has a span of 140 feet, a height of more than 125 feet and a width of about 400 feet. In fact the bridge is so large that the visitor is likely to walk over it, as the writer did, without knowing he is on it. The top of the bridge is under irrigation and produces crops of alfalfa.

The formation of the bridge is simple and the process can sometimes be seen when moist, drifting snow forms a bridge across a small valley. Several large springs that empty into the valley on the east contain lime in solution which, upon evaporation or loss of carbonic acid gas, is deposited. For many years this deposit has been accumulating and with sufficient rapidity to force the stream (Pine Creek) to the west side of the valley. In one place the deposition was rapid enough

and the travertine strong enough to arch over the creek and buttress itself on the opposite bank, thus forming a natural bridge. The deposition does not seem to be going on as actively now as formerly, but in one place the lime is being deposited so rapidly that hats, shoes and other objects left in the spray are coated over with a thick layer of lime in a few months. Underneath the bridge are caves of considerable size adorned with stalactites and stalagmites.

The greatest natural bridges of the United States, and of the world, are found in southeastern Utah. These were formed in a manner so simple that the explanation may, at first, seem inadequate. The streams which they now span have great bends and formerly had greater ones. As they deepened their beds they kept cutting away on the inside of these curves. In some cases the streams probably cut through the necks of these meanders without the formation of bridges, but in four instances the stream perforated the neck of the bend, forming natural bridges. These Utah natural bridges are enormous, varying in height from 108 to 308 feet, and in length of span from 186 to 275 feet. The bridges are made of red sandstone and occur in a high plateau in which the streams have cut canyons hundreds of feet deep.

An interesting bridge of a similar origin spans Swifts Camp Creek (Figs. 9 and 10) in the mountains of eastern Kentucky. Although the top of the bridge is but 15 or 20 feet above the surface of the stream and the length of the span is only 50 feet, yet it illustrates as well as the great Utah natural bridges the manner in which the stream has worked to accomplish this result. The greatest natural bridge in Europe, the Pont D'Arc across the Ardêche has a similar origin, as can readily

FIG. 12. A NATURAL BRIDGE BELOW CREELSBORO, RUSSEL COUNTY, KENTUCKY, formed as shown in Fig. 11.

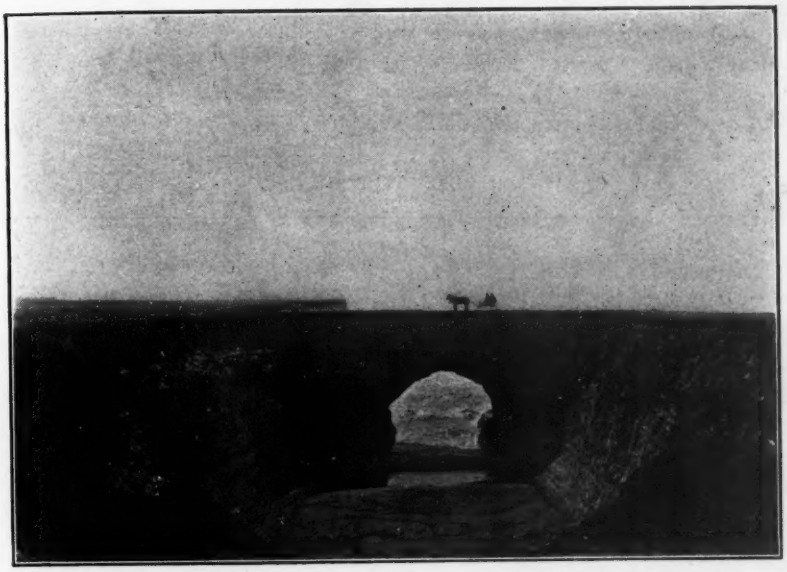

FIG. 13. A NATURAL ARCH NEAR SANTA CRUZ, CALIFORNIA, FORMED BY WAVE ACTION.

be seen by a study of a map of the region. Another Kentucky bridge formed by the lateral erosion of a tributary stream has produced a perforation (Figs. 11 and 12). The water flows through the opening into the tributary stream when the river is high and from the tributary to the river when the water in that is high. One at least of the Utah bridges may have been formed in this way.

On the coast of California is a natural arch (Fig. 13) made by the beating of the waves against a cliff of soft shale. The top of the arch is so level that a team of horses can be driven across it in safety. It was formed by the partial falling in of the roof of a sea cave. Openings of a similar nature are not uncommon on rough and stormy coasts but it is seldom that a structure so perfect as this is formed.

It will be seen from the above that natural bridges are formed in many ways; that they are not confined to any particular kind of rock, nor are they restricted to any particular region but are found alike in deserts and fertile lands, in mountains and on plateaus.

Natural bridges are short lived, geologically considered. The marble natural bridge in North Adams, Mass., for example, was formed many years after glacial times, but already a portion of the bridge has fallen in. Since the great ice sheet is believed to have disappeared from Massachusetts between 20,000 and 80,000 years ago and since this bridge was not formed until long after it had vanished, it will be seen that the life is not long as time goes. Nevertheless, short lived as they are geologically, some of them probably were in existence when the human race was very young.

SOME WEATHER PROVERBS AND THEIR JUSTIFICATION

By W. J. HUMPHREYS, Ph.D.

PROFESSOR OF METEOROLOGICAL PHYSICS, U. S. WEATHER BUREAU

"So it falls that all men are
With fine weather happier far."
—*King Alfred.*

THIS thousand-year-old observation by England's wisest ruler recognizes the fact that fine weather induces good tempers, and therefore amply justifies the proverb that shrewdly bids one "Do business with men when the wind is in the northwest."

But this effect on the minds of men does not exhaust the good and the evil of weather conditions, since our comfort, our convenience and even the success or failure of whatever we undertake, all depend, in large measure, upon clear skies and cloudy, upon wind and rain, and upon everything that renders the elements fair or foul.

Because, then, of the great influence weather conditions have over human affairs numerous rules for foretelling their coming changes have been formulated in all ages and by all peoples. While many of these rules are of general application, many others, as might be suspected, have only a local value, and owe their justification to some peculiar configuration of mountain and valley, or distribution of land and water, and, therefore, when transferred to other places commonly are meaningless, if not even misleading. Nevertheless, all of them, the wise and the silly, the good and the bad, have been inherited alike from the ends of the earth; and in this way many a concise saying has become a weather nugget in that great vein of wisdom and folly called folk lore.

Some of these nuggets are as pure gold, for they correctly state the actual order of sequence, as determined by innumerable observations, even when the cause for such an order was not in the least understood by those who discovered it; but most of them are as only fools' gold, pretty in form, but wholly deceptive. To this latter class belong hundreds of proverbs of the ground-hog and goose-bone type; some owing their origin to one thing and some to another, but, like predictions based upon the weather of saints' days, or upon the phase of the moon and the pointing of its horns, never for a moment accepted by those whose reason demands an adequate cause for every effect.

But that other class of weather proverbs, those that do have more or less to support them, is worthy of very careful consideration and study, for they embody accurate descriptions of phenomena and express the usual sequence of events.

It can be argued, of course, and apparently with good reason, that, in spite of its scientific interest, such a study can not now have any practical use, since nearly every country has a national weather service whose forecasts, for any given time and place, are reliably based upon the known immediately previous conditions all over a continent—conditions that are followed from hour to hour and day to day; that are minutely recorded and carefully studied.

It is true that when one is supplied with such information his horizon becomes world wide; that he sees the weather as it is everywhere; knows in what directions the storms are moving and how fast, and that, therefore, he can predict the approximate weather conditions for a day or more ahead. But in general it is not practicable officially to forecast for definite hours, nor for particular farms and villages. In the making, then, of hour-to-hour and village-to-village forecasts, though often of great value, one must rely upon his own interpretation of the signs before him. Besides, in many places it is impossible to get, in time for use, either the official forecast or the weather map upon which to base one's own opinions, and under these conditions certain weather signs are of especial value—signs which every one uses to a greater or less extent, but with an understanding of their significance that, according to such experience as only real necessity can give, varies from the well nigh full and complete to the vague and evanescent.

Thus the fisherman to-day, as in the past, will weigh anchor and flee from the gathering storm when to the uninitiated there is no indication of anything other than continued fair weather; and the woodsman, as did his remotest ancestors, will note significant changes and understand their warning messages when the average man would see no change at all, or, if he did, would fail to comprehend its meaning.

The prescience of these men is phenomenal, and it is with some of the useful weather proverbs they know so well, the causes of the phenomena they describe and the relation of these phenomena to others they precede, that the following is concerned.

Seasons

"A good year is always welcome."

Naturally every one asks: "What of the coming season?" And especially is this an important question for the farmer, for a correct answer to it would tell him what crops to plant and where; whether upon hill or lowland, in light or heavy soil, and how best to cultvate them—vital points, every one, for his success. But whatever we may hope ultimately to accomplish, seasonal forecasting to-day is beyond the pale of scientific meteorology, though proverb meteorology is full of it. However, a few of the seasonal proverbs that deal with results rather than types of weather are rationally founded.

Among them we have:

"Frost year,
Fruit year."

"Year of snow,
Fruit will grow."

Or, in still another form:

"A year of snow, a year of plenty."

That these and similar statements commonly are true is evident from the fact that a more or less continuous covering of snow, incident to a cold winter, not only delays the blossoming of fruit trees till after the probable season of killing frosts, but also prevents that alternate thawing and freezing, so ruinous to wheat and other winter grains. In short, as another proverb puts it,

"A late spring never deceives."

A different class of proverbs, but one meaning practically the same thing as the foregoing, and justified by substantially the same fact, that is, that an unseasonably early growth of vegetation is likely to be injured by later freezes, is illustrated by the following examples:

"January warm, the Lord have mercy!"

"If you see grass in January,
Lock your grain in your granary."

"January blossoms fill no man's cellar."

"January wet, no wine you get."

"January and February,
Do fill or empty the granary."

"All the months in the year
Curse a fair Februeer."

There are hundreds of other proverbs dealing with seasonal forecasts, but, except those belonging to such classes as the above, they have very little to justify them. Many are purely fanciful and others utterly inane.

Sun

"Above the rest, the sun who never lies,
Foretells the change of weather in the skies."
—*Virgil.*

While proverbs concerning the seasons, in the most part, are built upon the shifting sands of fancy and of superstition, many, but not all, of those that concern the immediate future—the next few hours, or, at most, the coming day or two—are built upon the sure foundation of accurate observation and correct reasoning. Among these perhaps the best are those that have to do with the color of the sky and the appearances of the sun, the moon and the stars, for we see the first because of our atmosphere, and the others through it and, therefore,

any change in their appearances necessarily means changes in the atmosphere itself—changes that usually precede one or another type of weather.

A familiar proverb of this class runs as follows:

"A red sun has water in his eye."

Now the condition that most favors a red sun is a great quantity of dust—smoke particles are particularly good—in a damp atmosphere. Smoke alone, in sufficient quantity, will produce this effect, but it is intensified by the presence of moisture. The blue and other short wavelength colors, as we call them, of sun light are both scattered and absorbed to a greater extent by a given amount of dust or other substances, such as water vapor, than is the red; and this effect, since it is proportional to the square of the volume, becomes more pronounced as the particles coalesce. Hence when the atmosphere is heavily charged with dust particles that have become moisture laden, as they will in a humid atmosphere, and therefore relatively bulky, we see the sun as a fiery red ball. We know, too, that this dust has much to do with rainfall for, as was first proved many years ago by the physicist Aitken, cloud particles, and, therefore, rain, will not, under ordinary conditions, form in a perfectly dust-free atmosphere, but will readily form about dust motes of any kind in an atmosphere that is sufficiently damp.

A red sun, therefore, commonly indicates the presence of both of the essential rain elements, that is, dust and moisture; and while the above is not the whole story, either of the meteorological effects due to dust in the air, or of the formation of rain, it is sufficient to show how well founded the proverb under consideration really is. And also this other one that says:

"If red the sun begin his race,
Be sure the rain will fall apace."

Sky Colors

"Men judge by the complexion of the sky
The state and inclination of the day."
—*Shakespeare.*

There are many proverbs, ranging from the good and useful to the misleading and absurd, concerning the color of the sky at sunrise and sunset.

From Shakespeare we have the well-known lines:

"A red morn that ever yet betokened
Wreck to the seaman, tempest to the field,
Sorrow to the shepherds, woe unto the birds,
Gusts and foul flaws to herdsmen and to herds."

Besides these stately verses there are many proverb jingles that express substantially the same idea. One of them puts it thus:

"Sky red in the morning
Is a sailor's sure warning;

Sky red at night
Is the sailor's delight."

But in many ways the most interesting of all those proverbs that have to do with red sunrise and red sunset is the one which, according to Matthew, Christ used in answer to the Pharisees and Sadducees when they asked that He would show them a sign from heaven.

"He answered and said unto them, When it is evening, ye say, It will be fair weather: for the sky is red.

"And in the morning, It will be foul weather to-day: for the sky is red and lowring."

It would seem, too, that Christ sanctioned these views, for it does not appear reasonable that He would teach by illustrations which He knew to be false. Then, too, He follows the above with these words:

"O ye hypocrites, ye can discern the face of the sky; but can ye not discern the signs of the times?"

But whether or not Christ accepted these weather signs as being good, we feel certain that those to whom he spoke must have known and believed in them. It is, therefore, worth while to search, even though the search be a somewhat tedious one, for the physical explanation of these phenomena, and to see how it is possible, if it really is, for identically the same colors of the sky to have for the evening one meaning, and for the morning another entirely different.

To clear the way for this explanation it is necessary, first, to tell something of the composition of sunlight, and a little about the atmosphere through which it passes on its way to the surface of the earth.

We know that rain drops are colorless, and we know, too, that when we are between a falling shower and the bright sun they give us the exquisite coloring of the rainbow. We are also aware that prism-shaped, colorless and transparent objects will receive a ray of white sunlight and emit all the rainbow's brilliant hues, from the faintest violet to the deepest ruby; and that when these are recombined the result is white light like the original. Through such experiments and observations we infer that sunlight is composed, in part at least, of all pure colors, and that they gradually merge the one into the other.

Again, it is possible to obtain two sources of light of the same color and intensity such that at certain places they produce more than twice —in fact up to fourfold—the intensity of one alone, and at certain other places intensities less than that of just one, even to utter darkness. Now this tells us that in some respects two lights behave in a manner similar to two trains of water waves, for these may combine so as at some places to produce exceptionally large waves and at others practically smooth water. Indeed, it has been shown by numerous experiments that light has several properties in common with water waves; one of these being wave-length, that is, the distance from a point in one

wave to the corresponding point of its nearest neighbor, as, for instance, from crest to crest.

Of all colors violet light has the shortest wave-length, and red the longest. Blue is next to violet, yellow next to red, and green about an average of all. The wave-length of red light is less than twice that of the violet, and yet it would take more than 30,000 of the longest waves to which the eye is sensitive to span a single inch.

Turning, now, our attention to the atmosphere, we find that at nearly all times, and everywhere within two miles of the surface, and probably much higher still, it contains, in every cubic inch, thousands of dust particles coming from fires, from plants, from the dry earth as caught up by winds, and from still other sources. Much of this dust is excessively fine and settles down with extreme slowness. It serves, as already explained, as nuclei about which the myriads of cloud droplets are formed.

In addition to this important function, extremely fine particles of dust, and even single molecules, but not the coarser portions, as shown many years ago by Lord Rayleigh, both scatter and absorb light of all colors according to the laws: (1) that the amount both of absorption and of scattering decreases in the same proportion that the fourth power of the wave-length increases; (2) that both increase with the number of particles per unit volume, and with the average square of the volume of the individual particle.

The refractive index of the air and of the foreign substances it contains, together with certain numerical terms, also enter into the complicated equations that deal quantitatively with atmospheric absorption and scattering of light. These latter facts, since they are not essential to what follows, are mentioned here only for the sake of completeness.

Now scattering and absorption, acting according to the above laws, combine to give us the colors of the sky, because sky light is only the residual, after absorption, of that portion of sunlight which was scattered by the molecules of the atmosphere and by the foreign substances floating in it.

Since, according to the first law, but little light of very long wave-length is scattered while nearly all of exceedingly short wave-length is absorbed, it follows that the light of maximum intensity, or the prevailing color, must have some intermediate wave-length. Hence the sky overhead is neither red (long wave-length) nor violet (short wave-length). Also, from the second law, we see that different parts of the sky at the same time, and the same parts of the sky at different times, will have different colors owing to the amount, aggregation and distribution of atmospheric dust.

When these particles are relatively few and small the prevailing color is blue. On the other hand, where the dust motes increase in size

and number, as they do near the surface of the earth, or in size only, even at the expense of numbers, as happens in a moist atmosphere, because of their hygroscopic property, light of the shorter wave-lengths becomes more completely absorbed and the sky assumes some longer wave-length color. Finally, when the particles are large enough to reflect as mirrors the sky becomes whitish. Hence both the morning and the evening twilight sky often shows a series of colors ranging from red, near the horizon, through orange and yellow to a green or even blue-green with increase of elevation and consequent decrease in the number and size of dust particles along the path of light from the sun to that part of the sky in question and thence to the observer.

When the air is filled with fog, or other particles of similar size, the whole sky becomes uniformly gray. This is because the water droplets that together make fog and cloud, though usually so small that it would take from 2,000 to 3,000 of them to make a row an inch long, nevertheless are large enough to reflect, as would little mirrors, and to refract, or transmit in a new direction, light of every color.

It remains now, in preparing the way to an understanding of the weather significance of morning and evening colors, briefly to outline the essential conditions and processes of cloud formation and rain.

Probably that one of these conditions with which the general public is least familiar is the presence, in large numbers, of some sort of nuclei about which water vapor can condense. We can safely assume, too, that in the open atmosphere these nuclei consist only of dust particles, though it is possible in the laboratory, under conditions that rarely, if ever, exist naturally, to obtain condensation without the aid of dust of any kind.

Besides the presence of dust particles, a certain relation between temperature and water content of the atmosphere is also essential to condensation. The warmer the air, so long as the temperature is below the boiling point, the greater, and, for ordinary temperatures, at a rapidly increasing rate, the amount of water vapor it can contain in the form of a transparent gas.

In reality the relation above discussed is between the temperature and amount of moisture per unit volume, a quantity which does not appreciably change with the presence or absence of other gases. But it is allowable, because of this constancy, to use the popular, though unscientific, expression, "water content of the atmosphere," provided one thinks of the atmosphere as a mixture of gases (chiefly nitrogen and oxygen) coexisting with the undisturbed water vapor, and not as a sort of sponge that mechanically holds it in suspension.

If, then, air, which always has dust particles in it, containing all or nearly all the water vapor it can hold, is cooled to a distinctly lower temperature, a corresponding amount of condensation will take place

on each dust mote, and the countless droplets thus formed will appear as a fog or cloud of greater or less density.

The most efficient method of producing the cooling necessary to cloud formation is to move the moist air to a place of lower pressure, that is, lift it to a greater elevation, where it will expand and thereby do work against the surrounding decreased pressure at the expense of the heat energy it contains. This effect is well illustrated by the formation of cumuli, or thunderhead clouds, in the summer time; the process of which, in general, is as follows: The earth is heated by sunshine and it in turn heats and expands the adjacent atmosphere and thereby renders it lighter, volume for volume, than the surrounding cooler air. The light, warm atmosphere often nearly saturated with water evaporated from lakes, from moist earth and growing vegetation, and by this vapor rendered still lighter, is buoyed up by cooler and heavier adjacent air, very much as a cork is made to bob up when let go beneath a water surface. The lifted, or, as we commonly say, the rising air, sustains at any particular time only the weight of the atmosphere that is at that moment above it. But, clearly, so long as the air is rising this weight is growing less, and therefore as it passes from a region of greater to one of less pressure it expands just as a compressed spring does when its load is decreased. However, as the spring expands it must do the work of lifting the remaining weight, and so it is with the atmosphere; in expanding it has to lift the air that is above it and thereby do work. Now this work is possible only because of the heat of the active air itself, and consequently as it expands it correspondingly gets cooler. But, as has already been explained, the amount of water vapor that any given volume can hold in the form of a transparent gas, rapidly decreases as the temperature falls.

A rising mass of air, therefore, cools by virtue of its own work in expanding against pressure, and soon reaches a temperature below which it can not contain, as a gas, all its water-vapor. Hence any further rise and consequent cooling leads to precipitation—a collection of the excess water vapor in droplets about dust particles—and the formation of clouds.

With the foregoing facts in mind it is easy to understand, in a general way, those actions of nature that give meaning to the sky colors of morning and evening, and, in large measure justify the proverbs that for ages have been associated with them. Thus we see that a red evening sky means that nothing more than incipient condensation exists even at the tops of the strongly cooled convection currents that obtained during the heated portion of the afternoon (more than this would produce a gray or even cloudy sky), and that therefore the air contains so little moisture that rain, within the coming twenty-four hours, is improbable.

If the evening sky, not far up, but near the western horizon, is yellow, greenish, or some other short wave-length color, then all the greater is the chance for clear weather, for these colors indicate even less condensation (smaller particles) and therefore a dryer air than does red. Hence we can accept the following lines from Shakespeare as the expression of a general truth:

"The weary sun hath made a golden set,
And by the bright track of his fiery car
Gives token of a goodly day to-morrow."

If, however, the evening sky has none of these colors, but is overcast with a uniform gray, then we know that numerous water droplets are present, and that the dust particles, in spite of the heat they absorbed from sunshine, have become loaded with much moisture. Obviously, then, to produce this effect, the atmosphere, at considerable elevations, must be practically saturated, a condition that favors rain and justifies the familiar proverbs:

"If the sun set in gray
The next will be a rainy day."

"If the sun goes pale to bed
'Twill rain to-morrow, it is said."

The above discussion of color phenomena applies to the evening sky only. It remains to explain the origin of similar morning effects and to point out the differences in the processes by which they are brought about.

A gray morning sky means, just as does a gray evening one, that the atmosphere is filled with water globules which are large enough, and even the smallest of them are, to refract and specularly reflect light of every color. The difference, then, must be in the processes that lead to the formation of the evening and the morning droplets. And these processes are not the same, for the dust of the day sky is heated by sunshine, as are also, to a greater or less extent, both the air and the earth beneath, while the dust in the night sky, as does everything else that is freely exposed, loses of the heat it possesses and cools through radiation to space. Besides, the atmosphere during the day time, and especially in the afternoon, is cooled by convection, which, as already explained, leads to more or less condensation of moisture on the dust that is present; while at night there is no strong upward movement, there being no surface heating, and consequently but little dynamic cooling of the air. The slight condensation here considered is due by day chiefly to convectional cooling, by night mainly to loss of heat through radiation.

Evidently, then, the gray of the morning sky may often be caused by water droplets that have gathered as so much dew on the dust particles in the air—dew that has collected on them because of the slightly

lower temperature they maintain through radiation to space, just as, and for the same reason that it collects on blades of grass and other exposed good radiators. But in order that the marked radiation, essential to the formation of the water droplets, may take place, it is necessary that the atmosphere above them be dry, for water vapor does not allow radiation freely to pass through it. Hence a gray morning sky implies a dry atmosphere above the dew droplets, and, therefore, justifies the expectation of a fair day, or even a clear one, for the droplets themselves to which the gray is due are soon evaporated by the rising sun, and convection, in this case, because it mixes the moist lower with a dry upper air, seldom causes precipitation.

A red morning sky commonly implies that the lower and heavier dust particles have been protected from excessive night radiation by a blanket of overlying moisture, else it would be gray; and at the same time it also implies the presence, in the lower atmosphere, of sufficient moisture to enlarge the dust particles through incipient condensation, else the sky would have some shorter wave-length color, such as yellow to green. Hence when the morning sky is red the whole atmosphere, to considerable elevations, is moist, and rain, therefore, probable.

Convection in the main, as we have seen, prepares the way for the phenomena of the evening sky, and radiation for those of the morning sky. Hence the amount and distribution of moisture most favorable to any given sky color, such as a gray or a red, are radically different in the two cases. There is, therefore, a real physical basis for, and much truth in, the proverbs that declare one result to follow the red of morning and quite another that of evening. There is also justification for some proverbs, two of which have already been given, that refer to or include other colors.

Additional good examples of the latter are as follows:

"Evening gray and morning red
Make the shepherd hang his head."

"An evening gray and a morning red
Will send the shepherd wet to bed."

"Evening red and morning gray
Two sure signs of one fine day."

"Evening red and morning gray
Help the traveler on his way;
Evening gray and morning red
Bring down rain upon his head."

CORONAS AND HALOES

"For I fear a hurricane;
Last night the moon had a golden ring,
And to-night no moon we see."

—*Longfellow.*

Many proverbs foretelling rain and bad weather are based on the appearance of solar and lunar haloes and coronas, and as these form only when there is much moisture in the air and some condensation the proverbs of this class are well founded.

Coronas are the small colored rings of light that encircle any bright object when seen through a mist, though the term commonly is used to designate only the colored rings around the sun and moon. They are due to diffraction (the bending of light at the boundary of an object into its geometric shadow) caused by water globules, and have one or another angular diameter depending on the size of the droplets that produce them, in the sense that the larger the droplets the smaller the corona. Hence a decreasing corona implies growing drops and the probability of an early rain.

Haloes, on the other hand, are the rings of large diameter, usually colorless or nearly so, due to reflection and refraction by ice spicules, and are often seen in the high cirrus clouds that have been caught up from the tops of storms and carried forward by the swiftly moving air currents that always prevail at such elevations. It is this usual position of haloes relative to storm centers, that is, in front of them, that makes them the good indicators they are of approaching bad weather.

Typical of such proverbs is that of the Zuñi Indians, who say:

"When the sun is in his house it will rain soon."

Several others refer to the apparent diameter of the circle. Thus we have:

"Far burr, near rain."

"The bigger the ring, the nearer the wet."

"When the wheel is far the storm is n'ar;
When the wheel is n'ar the storm is far."

These latter can not refer to the corona, which actually does change in angular size, because in that case just the reverse is true; the bigger the ring the farther off the storm. Clearly then they apply only to the halo, and as the apparent size of an object of constant angular diameter depends upon its seeming distance away, it follows that the supposed changes referred to are optical illusions, due to erroneous impressions of distance.

A good illustration of this kind of illusion is furnished by the moon as seen by different people, or as seen by the same person at different elevations above the horizon. When high in the heavens, where it appears to be comparatively near, it looks smaller than it does when close to the horizon where it seems to be farther away; and yet careful measurements show but little change in its angular diameter, and that little just the reverse of appearances.

Hence, when the actual distance to a halo is less than it seems to be,

as often happens when the clouds are low, it appears to be unusually large; and, conversely, when the clouds are very high a halo in them, because the distance to it commonly is underestimated, impresses one as being correspondingly small.

Now the higher the clouds the swifter the winds that carry them along and the farther removed they become from the storm center. Hence, a halo that appears small is due to clouds far removed from the storm that produced them, while one that seems large, since it is caused by relatively low and, therefore, slow-moving clouds usually indicates that the storm is comparatively near.

Moon

"But chiefly look to Cynthia's varying face;
There surest signs of coming weather trace."
—*Aratus.*

Many people have supposed, and some still hold, that the moon appreciably controls the weather, and there are numerous proverbs based on this assumed relation. But careful study of the records shows that the moon's influence on the weather, beyond a very small tidal effect on the atmosphere, as indicated by the barometer, is negligible, if indeed it has any influence at all. As has been well said:

"The moon and the weather
May change together;
But change of the moon
Does not change the weather.
If we'd no moon at all,
And that may seem strange,
We still should have weather
That's subject to change."

However, the appearance of the moon depends upon the conditions of the atmosphere, and, therefore, proverbs based upon phenomena of this nature are more or less sound and have much value. Thus:

"Clear moon
Frost soon,"

"Moonlit nights have the heaviest frosts,"

and others of this class are true enough, because on the clearest nights the cooling of the earth's surface by radiation is greatest and hence most likely to cause, through the low temperature reached, precipitation in the form of dew or frost.

The meaning of haloes and coronas about the moon has already been explained, and the proverbs connected with them, foretelling bad weather, fully justified.

The following is a somewhat interesting moon proverb:

"Sharp horns do threaten windy weather."

When the air is clear bad seeing is due to atmospheric inequalities which the free mixing caused by winds will eliminate. When the moon's horns, then, appear sharp, that is, when the seeing is good, we know that these inequalities do not exist, and the natural inference is that they have been smoothed out by strong overrunning winds, which later may reach the surface of the earth.

STARS

"The prudent mariner oft marks afar
The coming of tempests by Boötes's star."
—*Aratus.*

The stars, like the sun and the moon, have furnished a number of proverbs concerning the weather, and, while most of them are only nonsense, a few have decided merit, as, for instance:

"When the stars begin to huddle,
The earth will soon become a puddle."

This proverb furnishes, in general, a correct forecast. It also affords a curious illustration of the ignorance that once was—perhaps it would not be far wrong to say still is—so prevalent in regard to stars.

When a mist, due to the beginning of condensation, forms over the sky the smaller stars cease to be visible, while the brighter ones shine dimly with a blur (really a faint corona) of light about them, each looking like a small confused cluster of stars. Hence the idea, as above expressed, that stars can huddle together at one time—before a rain—and be scattered asunder at another.

There is also some ground for the proverb that declares the number of stars within a lunar halo to be the number of days before a storm, for the nearer the storm the denser the condensation, and therefore the smaller the number of stars seen through it. However, as an entire day is a pretty long unit of time to use in sign forecasting, it would be better simply to say that the fewer the stars within the ring the nearer the rain; though even in this form it is not very trustworthy, owing to the fact that the brighter stars are unevenly distributed.

An entirely different star phenomenon that has given rise to a few proverbs is twinkling, or the irregularities with which they shine. This fluctuation in their light is caused mainly by irregular refraction due to numerous inequalities in the distribution of temperature, such as necessarily accompanies the over and under running of air currents of different temperatures and different humidities, a condition that often precedes a storm. Hence the justification of the prosaic proverb that says:

"When stars flicker in a dark back-ground rain or snow follows soon."

Wind

"Every wind has its weather."
—*Bacon.*

There are numerous proverbs based on the directions and changes of the wind, but their value, in the main, is only local, except when taken in connection with the height and rate of change of the barometer. However, in middle latitudes the direction of ordinary undisturbed winds is from west to east. Therefore, a radically different direction commonly indicates an approaching, or, at any rate, not very distant, storm. There is, then, some justification for such proverbs as the following:

"When the smoke goes west,
Gude weather is past;
When the smoke goes east,
Gude weather comes neist."

"When the wind's in the south,
The rain's in its mouth."

"The wind in the west
Suits every one best."

Clouds

"And now the mists from earth are clouds in heaven."
—*Wilson.*

The height, extent and shapes of clouds depend upon the humidity and upon the temperature and motion of the atmosphere, and consequently they often furnish reliable warnings of the coming weather.

One proverb correctly says:

"The higher the clouds, the finer the weather."

As already explained, the formation of clouds is caused mainly by cooling due to convection; the rising mass of air expanding and losing heat because of the work it does in lifting the weight that presses upon it. Now the greater the height reached the colder, correspondingly, is the air, and hence we correctly infer that high clouds are formed only at the expense of much cooling and, therefore, that the amount of moisture they contain can not be great enough to produce falling or bad weather.

This proverb must be restricted to stratus and other of the more common clouds. It does not apply to those thin wispy or cirrus clouds, the highest of all, that float from five to eight miles above sea-level, for, as every one knows:

"Mackerel scales and mares' tails
Make lofty ships carry low sails."

Part of the air that forms the strong upward currents near the

center of a storm rises to great heights where, in middle latitudes, it gets into the swiftly eastward moving layers that carry it and its ice particles far ahead of the rains. There are other ways by which such clouds can be formed, but that just explained is one of the most common, and as, in this case, they are only the overrunning portion of a storm that is coming on in the same general direction, the proverb just quoted evidently is well founded.

When the air is rather damp and the day is warm great cumulus or thunderhead clouds are apt to form, as a result of strong convection, and produce frequent local showers. Hence the following proverb:

"When clouds appear like rocks and towers,
The earth's refreshed by frequent showers."

Another interesting phenomenon, familiar to all who live among the mountains, is the formation of a cloud along the highest ridges, due, of course, to the upward deflection of the wind as it blows against their sloping sides. This mechanical, or forced, convection produces the usual cooling, which, when the air is damp, results in the formation of cloud. Hence the truth of the proverb that tells us:

"When the clouds are upon the hills,
They'll come down by the mills."

Sound

"There is a sound of abundance of rain."
—*Elijah.*

When the air is full of moisture its temperature tends rapidly to become equalized—the colder places are warmed by condensation and the warmer cooled by evaporation. In this way the atmosphere is freed from the innumerable temperature irregularities that prevail during dry weather, irregularities that, as Tyndal showed many years ago, strongly reflect and dissipate sound. We see, then, that when the air is homogeneous, which it is far more likely to be when damp, it will convey sound much better than it will when filled with inequalities, and hence there is good reason to accept the proverb, and other similar ones, that says:

"Sound traveling far and wide
A stormy day will betide."

Not only the hearing, but the seeing as well, is improved by the homogeneity of the atmosphere, and this, too, has its appropriate proverbs of which the following is a good example:

"The farther the sight, the nearer the rain."

Animals

"Grumphie smells the weather,
An' grumphie sees the wun';
He kens when clouds will gather,
An' smoor the blinkin' sun."

This extravagant tribute to the pig as a weather prophet is typical of a large number of proverbs, though, perhaps, no other animal has been credited with actually seeing the wind.

Doubtless the dampness and change in temperature that commonly precede storms somewhat modify the behavior of many animals, but of the numerous weather proverbs based upon their actions even the few that have any truth to support them have far greater physiological than meteorological interest, and consequently this is not a proper place for their further discussion.

Plants

"Pimpernel, pimpernel, tell me true
Whether the weather be fine or no."

A similar appeal might, with equally good reason, be made to the dandelion, to red clover, to the silver maple, and to numerous other plants, all of which commonly undergo some change, such as the closing of their flowers or an alteration in the attitude of their leaves, at the approach of rain.

These phenomena, however, do not long precede the actual storm, and therefore have but little warning value. They are due to such things as changes in moisture, temperature and sunshine and consequently, while inferior as useful weather signs, are the greatest help to those who would understand plant physiology.

Aches and Pains

"As old sinners have all points
O' th' compass in their bones and joints."
—*Butler.*

It is well recognized, and attested to by a family of proverbs, that those who are annoyed with rheumatic pains, as also the dyspeptic and the neurasthenic, often are more than usually troubled by their ills at the near approach of rainy and generally bad weather. It was for this reason that the wise, though we may suspect not overly joyful, editor, dedicated his almanac to "Torpid Liver and Inflammatory Rheumatism, the most insistent weather prophets known to suffering mortals."

However, such disagreeable signs are not universally available, for, fortunately, there are those who, like Tam O'Shanter, "never mind the storm a whistle." Therefore, while the influences of the weather and its changes on our feelings are worthy of careful study by both the

physiologist and the psychologist, such phenomena are of only secondary value as a popular means of weather prognostication. Besides, it is a method not assiduously cultivated—in fact, those who are provided with this particular means to a weather prescience would gladly be rid of it, while those who know it not believe in the old adage that says: "Where ignorance is bliss 'tis folly to be wise."

Miscellaneous

Under this heading one could include a great variety of proverbs—mostly foolish. However, there are two causes, decrease in atmospheric pressure and increase in humidity, that have led to a number of well-founded proverbs, or rather accurate observations, for they are seldom jingled in the typical proverb manner.

Thus we find it stated that the approach of a storm is marked by the rising of water in wells, by the more abundant flow of certain springs, by the bubbling of marshes, by the bad odors of ditches and by various other phenomena, all of which are due to that decrease of atmospheric pressure that ordinarily precedes a storm.

The increase of humidity—favorable to precipitation—is noted by the gathering of moisture on cold objects, the collection of perspiration on our own skins owing to diminished evaporation, and the dampness of many hygroscopic substances. The last effect is illustrated by the packing of salt, the tightening of cordage and of strings of musical instruments, the dull or damp appearance of stone walls and columns, the settling of smoke, and by a number of other similar phenomena, all of which have been appealed to, with more or less justification, as evidence of a gathering storm.

Of course many other weather proverbs, of which those quoted in this article are typical, might be given and explained, but it is hoped that enough from each class have been justified to indicate their importance in all those cases and circumstances where, unfortunately, a weather service can not take the place of weather signs.

SCIENCE AT THE MEDIEVAL UNIVERSITIES

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WITH the growth of interest in science and in nature study in our own day, one of the expressions that is probably oftenest heard is surprise that the men of preceding generations and especially university men did not occupy themselves more with the world around them and with the phenomena that are so tempting to curiosity. Science is usually supposed to be comparatively new and nature study only a few generations old. Men are supposed to have been so much interested in book knowledge and in speculations and theories of many kinds, that they neglected the realities of life around them while spinning fine webs of theory. Previous generations, of course, have indulged in theory, but then our own generation is not entirely free from that amusing occupation. Nothing could well be less true, however, that the men of preceding generations were not interested in science even in the sense of physical science, or that nature study is new, or that men were not curious and did not try to find out all they could about the phenomena of the world around them.

The medieval universities and the school-men who taught in them have been particularly blamed for their failure to occupy themselves with realities instead of with speculation. We are coming to recognize their wonderful zeal for education, the large numbers of students they attracted, the enthusiasm of their students since they made so many hand-written copies of the books of their masters, the devotion of the teachers themselves, who wrote at much greater length than do our professors even now and on the most abstruse subjects, so that it is all the more surprising to think they should have neglected science. The thought of our generation in the matter, however, is founded entirely on an assumption. Those who know anything about the writers of the Middle Ages at first hand are not likely to think of them as neglectful of science even in our sense of the term. Those who know them at second hand are, however, very sure in the matter.

The assumption is due to the neglect of science that came in the seventeenth and eighteenth centuries. We have many other similar assumptions because of the neglect of many phases of mental development and applied science at this time. For instance, most of us are very proud of our modern hospital development and think of this as a great humanitarian evolution of applied medical science. We are very

likely to think that this is the first time in the world's history that the building of hospitals has been brought to such a climax of development, and that the houses for the ailing in the olden time were mere refuges, prone to become death traps and at most makeshifts for the solution of the problem of the care of the ailing poor. This is true for the hospitals of the seventeenth and eighteenth centuries, but it is not true at all for the hospitals of the thirteenth and fourteenth and fifteenth centuries. Miss Nutting and Miss Dock in their "History of Nursing"[1] have called attention to the fact that the lowest period in hospital development is during the eighteenth and early nineteenth centuries. Hospitals were little better than prisons, they had narrow windows, were ill provided with light and air and hygienic arrangements and in general were all that we should imagine old-time hospitals to be. The hospitals of the earlier time, however, had fine high ceilings, large windows, abundant light and air, excellent arrangements for the privacy of patients, and in general were as worthy of the architects of the earlier times as the municipal buildings, the cathedrals, the castles, the university buildings and every other form of construction that the late medieval centuries devoted themselves to.

The trouble with those who assume that there was no study of science and practically no attention to nature study in the Middle Ages is that they know nothing at all about the works of the men who wrote in the medieval period at first hand. They have accepted declarations with regard to the absolute dependence of the scholastics on authority, their almost divine worship of Aristotle, their utter readiness to accept authoritative assertions provided they came with the stamp of a mighty name, and then their complete lack of attention to observation and above all to experiment. Nothing could well be more ridiculous than this ignorant assumption of knowledge with regard to the great teachers at the medieval universities. Just as soon as there is definitie knowledge of what these great teachers wrote and taught, not only does the previous mood of blame for them for not paying much more attention to science and nature at once disappear, but it gives place to the heartiest admiration for the work of these great thinkers. It is easy to appreciate then, what Professor Saintsbury said in a recent volume on the thirteenth century.

> **And there have even been in these latter days some graceless ones who have asked whether the science of the nineteenth century after an equal interval will be of any more positive value—whether it will not have even less comparative interest than that which appertains to the scholasticism of the thirteenth.**

Three men were the great teachers in the medieval universities at their prime. They have been read and studied with interest ever since. They wrote huge tomes, but men have pored over them in every genera-

[1] New York, Putnam, 1908.

tion. They were Albertus Magnus, the teacher of the other two, Thomas Aquinas and Roger Bacon. All three of them were together at the University of Paris shortly after the middle of the thirteenth century. Any one who wants to know anything about the attitude of mind of the medieval universities, their professors and students and of all the intellectual world of the time towards science and observation and experiment, should read the books of these men. Any other mode of getting at any knowledge of the real significance of the science of this time is mere pretense. These constitute the documents behind any scientific history of the development of science at this time.

It is extremely interesting to see the attitude of these men with regard to authority. In Albert's tenth book (of his "Summa") in which he catalogues and describes all the trees, plants and herbs known in his time he observes: "All that is here set down is the result of our own experience, or has been borrowed from authors whom we know to have written what their personal experience has confirmed; for in these matters experience alone can be of certainty." In his impressive Latin phrase "*experimentum solum certificat in talibus.*" With regard to the study of nature in general he was quite as emphatic. He was a theologian as well as a scientist, yet in his treatise on "The Heavens and The Earth" he declared that "in studying nature we have not to inquire how God the Creator may, as He freely wills, use His creatures to work miracles and thereby show forth His power. We have rather to inquire what nature with its immanent causes can naturally bring to pass."[2]

Just as striking quotations on this subject might be made from Roger Bacon. Indeed, Bacon was quite impatient with the scholars around him who talked over much, did not observe enough, depended to excess on authority and in general did as mediocre scholars always do, made much fuss on second-hand information—plus some filmy speculations of their own. Friar Bacon, however, had one great pupil whose work he thoroughly appreciated because it exhibited the opposite qualities. This was Petrus—we have come to know him as Peregrinus—whose observations on magnetism have excited so much attention in recent years with the republications of his epistle on the subject. It is really a monograph on magnetism written in the thirteenth century. Roger Bacon's opinion of it and of its author furnishes us the best possible index of his attitude of mind towards observation and experiment in science.

I know of only one person who deserves praise for his work in experimental philosophy for he does not care for the discourses of men and their wordy warfare, but quietly and diligently pursues the works of wisdom. Therefore what others grope after blindly, as bats in the evening twilight, this man contemplates in all their brilliancy *because he is a master of experiment.*

[2] "De cœlo et mundo," 1, tr. iv., x.

Hence, he knows all of natural science whether pertaining to medicine and alchemy, or to matters celestial or terrestrial. He has worked diligently in the smelting of ores as also in the working of minerals; he is thoroughly acquainted with all sorts of arms and implements used in military service and in hunting, besides which he is skilled in agriculture and in the measurement of lands. It is impossible to write a useful or correct treatise in experimental philosophy without mentioning this man's name. Moreover, he pursues knowledge for its own sake; for if he wished to obtain royal favor, he could easily find sovereigns who would honor and enrich him.

Similar expressions might readily be quoted from Thomas Aquinas, but his works are so easy to secure and his whole attitude of mind so well known, that it scarcely seems worth while taking space to do so. Aquinas is still studied very faithfully in many universities and within the last few years one of his great text-books of philosophy has been replaced in the curriculum of Oxford University, in which it occupied a prominent position in the long ago, as a work that may be offered for examination in the department of philosophy. It is with regard to him particularly that there has been the greatest revulsion of feeling in recent years and a recognition of the fact that here was a great thinker familiar with all that was known in the physical sciences, and who had this knowledge constantly in his mind when he drew his conclusions with regard to philosophical and theological questions.

As for the supposed swearing by Aristotle which is so constantly asserted to have been the habit of these scholastic philosophers, it is extremely difficult in the light of expressions which they themselves use to understand how this false impression arose. Aristotle they thoroughly respected. They constantly referred to his works, but so has every thinking generation ever since. Whenever he had made a declaration they would not accept the contradiction of it without a good reason, but whenever they had good reasons, Aristotle's opinion was at once rejected without compunction. Albertus Magnus, for instance, said: "Whoever believes that Aristotle was a God must also believe that he never erred, but if we believe that Aristotle was a man, then doubtless he was liable to err just as we are." A number of direct contradictions of Aristotle we have from Albert. A well-known one is that with regard to Aristotle's assertion that lunar rainbows appeared only twice in fifty years. Albert declared that he himself had seen two in a single year.

Indeed, it seems very clear that the whole trend of thought among the great teachers of the time was away from acceptance of scientific conclusions on authority unless there was good evidence for them available. They were quite as impatient as the scientists of our time with a constant putting forward of Aristotle as if that settled the scientific question. Roger Bacon wanted the Pope to forbid the study of Aristotle because his works were leading men astray from the study of

science, his authority being looked upon as so great that men did not think for themselves but accepted his assertions. Smaller men are always prone to do this, and indeed it constitutes one of the difficulties in the way of advance in scientific knowledge, as Roger Bacon himself pointed out.

These are the sort of expressions that are to be expected from Friar Bacon from what we know of other parts of his work. His "Opus Tertium" was written at the request of Pope Clement IV., because the Pope had heard many interesting accounts of what the great thirteenth-century teacher and experimenter was doing at the University of Oxford, and wished to learn for himself the details of his work. Bacon starts out with the principle that there are four grounds of human ignorance. These are, "first, trust in inadequate authority; second, that force of custom which leads men to accept without properly questioning what has been accepted before their time; third, the placing of confidence in the assertions of the inexperienced; and fourth, the hiding of one's own ignorance behind the parade of superficial knowledge, so that we are afraid to say I do not know." Professor Henry Morley, a careful student of Bacon's writings, said with regard to these expressions of Bacon:

> No part of that ground has yet been cut away from beneath the feet of students, although six centuries have passed. We still make sheep-walks of second, third and fourth, and fiftieth hand references to authority; still we are the slaves of habit, still we are found following too frequently the untaught crowd, still we flinch from the righteous and wholesome phrase "I do not know" and acquiesce actively in the opinion of others that we know what we appear to know.

In his "Opus Majus" Bacon had previously given abundant evidence of his respect for the experimental method. There is a section of this work which bears the title Scientia Experimentalis. In this Bacon affirms that "without experiment nothing can be adequately known. An argument may prove the correctness of a theory, but does not give the certitude necessary to remove all doubt, nor will the mind repose in the clear view of truth unless it finds its way by means of experiment." To this he later added in his "Opus Tertium": "The strongest argument proves nothing so long as the conclusions are not verified by experience. Experimental science is the queen of sciences, and the goal of all speculation."

It is no wonder that Dr. Whewell in his "History of the Inductive Sciences" should have been unstinted in his praise of Roger Bacon's work and writings. In a well-known passage he says of the "Opus Majus":

> Roger Bacon's "Opus Majus" is the encyclopedia and "Novum Organon" of the thirteenth century, a work equally wonderful with regard to its wonderful scheme and to the special treatises by which the outlines of the plans are

filled up. The professed object of the work is to urge the necessity of a reform in the mode of philosophizing, to set forth the reasons why knowledge had not made greater progress, to draw back attention to the sources of knowledge which had been unwisely neglected, to discover other sources which were yet almost untouched, and to animate men in the undertaking of a prospect of the vast advantages which it offered. In the development of this plan all the leading portions of science are expanded in the most complete shape which they had at that time assumed; and improvements of a very wide and striking kind are proposed in some of the principal branches of study. Even if the work had no leading purposes it would have been highly valuable as a treasure of the most solid knowledge and soundest speculations of the time; even if it had contained no such details it would have been a work most remarkable for its general views and scope.

As a matter of fact the universities of the middle ages, far from neglecting science, were really scientific universities. Because the universities of the early nineteenth century occupied themselves almost exclusively with languages and especially formed students' minds by means of classical studies, we in our generation are prone to think that such linguistic studies formed the main portion of the curriculum of the universities in all the old times and particularly in the middle ages. The study of the classic languages, however, came into university life only after the renaissance. Before that the undergraduates of the universities had occupied themselves almost entirely with science. It was quite as much trouble to introduce linguistic studies into the old universities in the renaissance time to replace science, as it was to secure room for science by pushing out the classics in the modern time. Indeed the two revolutions in education are strikingly similar when studied in detail. Men who had been brought up on science before the renaissance were quiet sure that that formed the best possible means of developing the mind. In the early nineteenth century men who had been formed on the classics were quite as sure that science could not replace them with any success.

There is no pretense that this view of the medieval universities is a new idea in the history of education. Those who have known the old universities at first hand by the study of the actual books of their professors and by familiarity with their courses of study, have not been inclined to make the mistake of thinking that the medieval university neglected science. Professor Huxley in his "Inaugural Address as Rector of Aberdeen University" some thirty years ago stated very definitely his recognition of medieval devotion to science. His words are well worth remembering by all those who are accustomed to think of our time as the first in which the study of science was taken up seriously in our universities. Professor Huxley said:

The scholars of the medieval universities seem to have studied grammar, logic and rhetoric; arithmetic and geometry; astronomy, theology and music. Thus their work, however imperfect and faulty, judged by modern lights, it

may have been, brought them face to face with all the leading aspects of the many-sided mind of man. For these studies did really contain, at any rate in embryo, sometimes it may be in caricature, what we now call philosophy, mathematical and physical science and art. *And I doubt if the curriculum of any modern university shows so clear and generous a comprehension of what is meant by culture, as this old Trivium and Quadrivium does.*

It would be entirely a mistake, however, to think that these great writers and teachers who influenced the medieval universities so deeply and whose works were the text-books of the universities for centuries after, only had the principles of physical and experimental science and did not practically apply them. As a matter of fact their works are full of observation. Once more, the presumption that they wrote only nonsense with regard to science comes from those who do not know their writings at all, while great scientists who have taken the pains to study their works are enthusiastic in praise. Humboldt, for instance, says of Albertus Magnus, after reading some of his works with care:

Albertus Magnus is equally active and influential in promoting the study of natural science and of the Aristotelian philosophy. His works contain some exceedingly acute remarks on the organic structure and physiology of plants. One of his works bearing the title of "Liber Cosmographicus De Natura Locorum" is a species of physical geography. I have found in it considerations on the dependence of temperature concurrently on latitude and elevation and on the effect of different angles of the sun's rays in heating the ground which have excited my surprise.

It is with regard to physical geography of course that Humboldt is himself a distinguished authority.

Humboldt's expression that he found some exceedingly acute remarks on the organic structure and physiology of plants in Albert the Great's writings will prove a great surprise to many people. Meyer, the German historian of botany, however, has reechoed Humboldt's praise with emphasis. The extraordinary erudition and originality of Albert's treatise on plants drew from Meyer the comment:

No botanist who lived before Albert can be compared with him unless Theophrastus, with whom he was not acquainted; and after him none has painted nature in such living colors or studied it so profoundly until the time of Conrad Gessner and Cæsalpino.

These men, it may be remarked, come three centuries after Albert's time. A ready idea of Albert's contributions to physical science can be obtained from his life by Sighart, which has been translated into English by Dixon and was published in London in 1870. Pagel, in Puschmann's "History of Medicine," already referred to, gives a list of the books written by Albert on scientific matters with some comments which are eminently suggestive, and furnish solid basis for the remark that I have made, that men's minds were occupied with nearly the same problems in science in the thirteenth century as we are now, while the conclusions they came to were not very different from ours, though reached so long before us.

This catalogue of Albertus Magnus's works shows very well his own interest and that of his generation in physical science of all kinds. There were eight treatises on Aristotle's physics and on the underlying principles of natural philosophy and of energy and of movement; four treatises concerning the heavens and the earth, one on physical geography which also contains, according to Pagel, numerous suggestions on ethnography and physiology. There are two treatises on generation and corruption, six books on meteors, five books on minerals, three books on the soul, two books on the intellect, a treatise on nutritives, and then a treatise on the senses and another on the memory and on the imagination. All the phases of the biological sciences were especially favorite subjects of his study. There is a treatise on the motion of animals, a treatise in six books on vegetables and plants, a treatise on breathing things, a treatise on sleep and waking, a treatise on youth and old age and a treatise on life and death. His treatise on minerals contains, according to Pagel, a description of ninety-five different kinds of precious stones. Albert's volumes on plants were reproduced with Meyer, the German botanist, as editor (Berlin, 1867). All of Albert's books are available in modern editions.

Pagel says of Albertus Magnus that

> His profound scholarship, his boundless industry, the almost incontrollable impulse of his mind after universality of knoweldge, the many-sidedness of his literary productivity, and finally the almost universal recognition which he received from his contemporaries and succeeding generations, stamp him as one of the most imposing characters and one of the most wonderful phenomena of the middle ages.

In another passage Pagel has said:

> While Albert was a Churchman and an ardent devotee of Aristotle, in matters of natural phenomena he was relatively unprejudiced and presented an open mind. He thought that he must follow Hippocrates and Galen, rather than Aristotle and Augustine, in medicine and in the natural sciences. We must concede it a special subject of praise for Albert that he distinguished very strictly between natural and supernatural phenomena. The former he considered as entirely the object of the investigation of nature. The latter he handed over to the realm of metaphysics.

Roger Bacon is, however, the one of these three great teachers who shows us how thoroughly practical was the scientific knowledge of the universities and how much it led to important useful discoveries in applied science and to anticipations of what is most novel even in our present-day sciences. Some of these indeed are so startling, that only that we know them not by tradition but from his works, where they may be readily found without any doubt of their authenticity, we should be sure to think that they must be the result of later commentators' ideas. Bacon was very much interested in astronomy, and not only suggested the correction of the calendar, but also a method by

which it could be kept from wandering away from the actual date thereafter. He discovered many of the properties of lenses and is said to have invented spectacles and announced very emphatically that light did not travel instantaneously but moved with a definite velocity. He is sometimes said to have invented gunpowder, but of course he did not, though he studied this substance in various forms very carefully and drew a number of conclusions in his observations. He was sure that some time or other man would learn to control the energies exhibited by explosives and that then he would be able to accomplish many things that seemed quite impossible under their present conditions.

He said, for instance:

> Art can construct instruments of navigation, such that the largest vessels governed by a single man will traverse rivers and seas more rapidly than if they were filled with oarsmen. One may also make carriages which without the aid of any animal will run with remarkable swiftness.

In these days when the automobile is with us and when the principal source of energy for motor purposes is derived from explosives of various kinds this expression of Roger Bacon represents a prophecy marvelously surprising in its fulfilment. It is no wonder that the book whence it comes bears the title "De Secretis Artis et Naturæ." Roger Bacon even went to the extent, however, of declaring that man would some time be able to fly. He was even sure that with sufficient pains he could himself construct a flying machine. He did not expect to use explosives for his motor power, however, but thought that a windlass properly arranged, worked by hand, might enable a man to make sufficient movement to carry himself aloft or at least to support himself in the air, if there were enough surface to enable him to use his lifting power to advantage. He was in intimate relations by letter with many other distinguished inventors and investigators besides Peregrinus and was a source of incentive and encouragement to them all.

The more one knows of Aquinas the more surprise there is at his anticipation of many modern scientific ideas. At the conclusion of a course on cosmology delivered at the University of Paris he said that "nothing at all would ever be reduced to nothingness" (*nihil omnino in nihilum redigetur*). He was teaching the doctrine that man could not destroy matter and God would not annihilate it. In other words, he was teaching the indestructibility of matter even more emphatically than we do. He saw the many changes that take place in material substances around us, but he taught that these were only changes of form and not substantial changes and that the same amount of matter always remained in the world. At the same time he was teaching that the forms in matter by which he meant the combinations of energies which distinguish the various kinds of matter are not destroyed. In

other words, he was anticipating not vaguely, but very clearly and definitely, the conservation of energy. His teaching with regard to the composition of matter was very like that now held by physicists. He declared that matter was composed of two principles, prime matter and form. By *forma* he meant the dynamic element in matter, while by *materia prima* he meant the underlying substratum of material, the same in every substance, but differentiated by the dynamics of matter.

It used to be the custom to make fun of these medieval scientists for believing in the transmutation of metals. It may be said that all three of these greatest teachers did not hold the doctrine of the transmutation of metals in the exaggerated way in which it appealed to many of their contemporaries. The theory of matter and form, however, gave a philosophical basis for the idea that one kind of matter might be changed into another. We no longer think that notion absurd. Sir William Ramsay has actually succeeded in changing one element into another and radium and helium are seen changing into each other, until now we are quite ready to think of transmutation placidly. The Philosopher's Stone used to seem a great absurdity until our recent experience with radium, which is to some extent at least the philosopher's stone, since it brings about the change of certain supposed elements into others. A distinguished American chemist said not long ago that he would like to extract all the silver from a large body of lead ore in which it occurs so commonly, and then come back after twenty years and look for further traces of silver, for he felt sure that they would be found and that lead ore is probably always producing silver in small quantities and copper ore is producing gold.

Most people will be inclined to ask where the fruits of this undergraduate teaching of science are to be found. They are inclined to presume that science was a closed book to the men and women of that time. It is not hard, however, to point the effect of the scientific training in the writings of the times. Dante is a typical university man of the period. He was at several Italian universities, was at Paris and perhaps at Oxford. His writings are full of science. Professor Kühns, of Wesleyan, in his book "The Treatment of Nature in Dante," has pointed out how much Dante knows of science and of nature. Few of the poets not only of his own but of any time have known more. There are only one or two writers of poetry in our time who go with so much confidence to nature and the scientific interpretation of her for figures for their poetry. The astronomy, the botany, the zoology of Albertus Magnus and Thomas Aquinas, Dante knew very well and used confidently for figurative purposes. Any one who is inclined to think nature study a new idea in the world forgets, or has never known, his Dante. The birds and the bees, the flowers, the leaves, the varied aspects of clouds and sea, the phenomena of phosphorescence, the inti-

mate habits of bird and beast and the ways of the plants, as well as all the appearances of the heavens, Dante knew very well and in a detail that is quite surprising when we recall how little nature study is supposed to have attracted the men of his time. Only that his readers appreciated it all, Dante would surely not have used his scientific erudition so constantly.

So much for the undergraduate department of the universities of the middle ages, and the view is absolutely fair, for these were the men to whom the students flocked by thousands. They were teaching science, not literature. They were discussing physics as well as metaphysics, psychology in its phenomena as well as philosophy, observation and experiment as well as logic, the ethical sciences, economics, practically all the scientific ideas that were needed in their generation—and that generation saw the rise of the universities, the finishing of the cathedrals, the building of magnificent town halls and castles and beautiful municipal buildings of many kinds, including hospitals, the development of the Hansa League in commerce and of wonderful manufacturers of all the textiles, the arts and crafts, as well as the most beautiful book-making and art and literature. We could be quite sure that the men who solved all the other problems so well could not have been absurd only in their treatment of science. Any one who reads their books will be quite sure of that.

While most people might be ready then to confess that possibly Huxley was not mistaken with regard to the undergraduate department of the universities, most of them would feel sure that at least the graduate departments were sadly deficient in accomplishment. Once more this is entirely an assumption. The facts are all against any such idea.

There were three graduate departments in most of the universities —theology, law and medicine. While physical scientists are usually not cognizant of it apparently, theology is a science, a department of knowledge developed scientifically, and most of these medieval universities did more for its scientific development than the schools of any other period. Quite as much may be said for philosophy, for there are many who hesitate to attribute any scientific quality to modern developments in the matter. As for law, this is the great period of the foundation of scientific law development, the English common law was formulated by Bracton, the deep foundations of basic French and Spanish law were laid, and canon law acquired a definite scientific character which it was always to retain. All this was accomplished almost entirely by the professors in the law departments of the universities.

It was in medicine, however, where most people would be quite sure without any more ado that nothing worth while talking about was

being done, that the great triumphs of graduate teaching at the medieval universities were secured. Here more than anywhere else is there room for supreme surprise at the quite unheard-of anticipations of our modern medicine and stranger still, as it may seem, of our modern surgery.

The law regulating the practise of medicine in the Two Sicilies about the middle of the thirteenth century shows us the high standard of medical education. Students were required to have three years of preliminary study at the university, four years in the medical department and then practise for a year with a physician before they were allowed to practise for themselves. If they wanted to practise surgery, an extra year in the study of anatomy was required. I published the text of this law, which was issued by the Emperor Frederick II. about 1241, in the *Journal of the American Medical Association* three years ago. It also regulated the practise of pharmacy. Drugs were manufactured under the inspection of the government and there was a heavy penalty for substitution, or for the sale of old inert drugs, or improperly prepared pharmaceutical materials. If the government inspector violated his obligations as to the oversight of drug preparations the penalty was death. Nor was this law of the Emperor Frederick an exception. We have the charters of a number of medical schools issued by the popes during the next century, all of which require seven years or more of university study, four of them in the medical department before the doctor's degree could be obtained. When new medical schools were founded they had to have professors from certain well-recognized schools on their staff at the beginning in order to assure proper standards of teaching, and all examinations were conducted under oath-bound secrecy and with the heaviest obligations on professors to be assured of the knowledge of students before allowing them to pass.

It might be easy to think, and many people are prone to do so, that in spite of the long years of study required there was really very little to study in medicine at that time. Those who think so should read Professor Clifford Allbutt's address on the "Historical Relations of Medicine and Surgery" delivered at the World's Fair at St. Louis in 1904. He has dwelt more on surgery than on medicine, but he makes it very clear that he considers that the thinking professors of medicine of the later Middle Ages were doing quite as serious work in their way as any that has been done since. They were carefully studying cases and writing case histories, they were teaching at the bedside, they were making valuable observations and they were using the means at their command to the best advantage. Of course there are many absurdities in their therapeutics, but then we must not forget there have always been many absurdities in therapeutics and that we are not free from

them in our day. Professor Richet, at the University of Paris, said not long ago "the therapeutics of any generation is quite absurd to the second succeeding generation." We shall not blame the medieval generations for having accepted remedies that afterwards proved inert, for every generation has done that, even our own.

Their study of medicine was not without lasting accomplishment however. They laid down the indications and the dosage for opium. They used iron with success, they tried out many of the bitter tonics among the herbal medicines, and they used laxatives and purgatives to good advantage. Down at Montpelier, Gilbert, the Englishman, suggested red light for smallpox because it shortened the fever, lessened the lesions and made the disfigurement much less. Finsen was given the Nobel prize partly for rediscovery of this. They segregated erysipelas and so prevented its spread. They recognized the contagiousness of leprosy and though it was probably as wide-spread as tuberculosis is at the present time, they succeeded not only in controlling but in eventually obliterating it throughout Europe.

It was in surgery, however, that the greatest triumphs of teaching of the medieval universities were secured. Most people are inclined to think that surgery developed only in our day. The great surgeons of the thirteenth and fourteenth century, however, anticipated most of our teaching. They investigated the causes of the failure of healing by first intention, recognized the danger of wounds of the neck, differentiated the venereal diseases, described rabies and knew much of blood poisoning, and operated very skilfully. We have their text-books of surgery and they are a never-ending source of surprise. They operated on the brain, on the thorax, on the abdominal cavity, and did not hesitate to do most of the operations that modern surgeons do. They operated for hernia by the radical cure, though Mondeville suggested that more people were operated on for hernia for the benefit of the doctor's pocket than for the benefit of the patient. Guy de Chauliac declared that in wounds of the intestines patients would die unless the intestinal lacerations were sewed up and he described the method of suture and invented a needle holder. We have many wonderful instruments from these early days preserved in pictures at least, that show us how much modern advance is merely reinvention.

They understood the principles of aseptic surgery very well. They declared that it was not necessary "that pus should be generated in wounds." Professor Clifford Allbutt says:

> They washed the wound with wine, scrupulously removing every foreign particle; then they brought the edges together, not allowing wine or anything else to remain within—dry adhesive surfaces were their desire. Nature, they said, produces the means of union in a viscous exudation, or natural balm, as it was afterwards called by Paracelsus, Paré and Wurtz. In older wounds they

did their best to obtain union by cleansing, desiccation and refreshing of the edges. Upon the outer surface they laid only lint steeped in wine. Powders they regarded as too desiccating, for powder shuts in decomposing matters; wine after washing purifying and drying the raw surfaces evaporates.

Almost needless to say these are exactly the principles of aseptic surgery. The wine was the best antiseptic that they could use and we still use alcohol in certain cases. It would seem to many quite impossible that such operations as are described could have been done without anesthetics, but they were not done without anesthetics. There were two or three different forms of anesthesia used during the thirteenth and fourteenth centuries. One method employed by Ugo da Lucca consisted of the use of an inhalant. We do not know what the material employed was. There are definite records, however, of its rather frequent employment.

What a different picture of science at the medieval universities all this makes from what we have been accustomed to hear and read with regard to them. It is difficult to understand where the old false impressions came from. The picture of university work that recent historical research has given us shows us professors and students busy with science in every department, making magnificent advances, many of which were afterwards forgotten, or at least allowed to lapse into desuetude.

The positive assertions with regard to old-time ignorance were all made in the course of religious controversy. In English-speaking countries particularly it became a definite purpose to represent the old church as very much opposed to education of all kinds and above all to scientific education. There is not a trace of that to be found anywhere, but there were many documents that were appealed to to confirm the protestant view. There was a papal bull, for instance, said to forbid dissection. When read it proves to forbid the cutting up of bodies to carry them to a distance for burial, an abuse which caused the spread of disease, and was properly prohibited. The church prohibition was international and therefore effective. At the time the bull was issued there were twenty medical schools doing dissection in Italy and they continued to practise it quite undisturbed during succeeding centuries. The papal physicians were among the greatest dissectors. Dissections were done at Rome and the cardinals attended them. Bologna at the height of its fame was in the Papal States. All this has been ignored and the supposed bull against anatomy emphasized as representing the keynote of medical and surgical history. Then there was a papal decree forbidding the making of gold and silver. This was said to forbid chemistry or alchemy and so prevent scientific progress. The history of the medical schools of the time shows that it did no such thing. The great alchemists of the time doing really scientific work were all clergymen, many of them very prominent ecclesiastics.

Just in the same way there were said to be decrees of the church councils forbidding the practise of surgery. President White says in his "Warfare of Religion with Theology in Christendom," that as a consequence of these surgery was in dishonor until the Emperor Winceslaus, at the beginning of the fifteenth century, ordered that it should be restored to estimation. As a matter of fact during the two centuries immediately preceding the first years of the fifteenth century, surgery developed very wonderfully and we have probably the most successful period in all the history of surgery except possibly our own. The decrees forbade monks to practise surgery because it led to certain abuses. Those who found these decrees and wanted to believe that they prevented all surgical development simply quoted them and assumed there was no surgery. The history of surgery at this time is one of the most wonderful chapters in human progress.

The more we know of the Middle Ages the more do we realize how much they accomplished in every department of intellectual effort. Their development of the arts and crafts has never been equalled in the modern time. They made very great literature, marvelous architecture, sculpture that rivals the Greeks, painting that is still the model for our artists, surpassing illuminations; everything that they touched became so beautiful as to be a model for all the after time. They accomplished as much in education as they did in all the other arts, their universities had more students than any that have existed down to our own time and they were enthusiastic students and their professors were ardent teachers, writers, observers, investigators. While we have been accustomed to think of them as neglecting science their minds were occupied entirely with science. They succeeded in anticipating much more of our modern thought and even scientific progress than we have had any idea until comparatively recent years. The work of the later middle ages in mathematics is particularly strong and was the incentive for many succeeding generations. Roger Bacon insisted that without mathematics there was no possibility of real advance in physical science. They had the right ideas in every way. While they were occupied more with the philosophical and ethical sciences than we are, these were never pursued to the neglect of the physical sciences in the strictest sense of that term.

Is it not time that we should drop the foolish notions that are very commonly held because we know nothing about the middle ages—and therefore the more easily assume great knowledge, and get back to appreciate the really marvellous details of educational and scientific development which are so interesting and of so much significance at this time?

THE SEARCH FOR THE SOUL IN CONTEMPORARY THOUGHT

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THE history of the soul appears to be the history of a vanishing quantity. It has indeed come now to have hardly more than an anthropological interest.[1] In recent text-books of psychology the word "soul" does not occur and the word "mind" seldom or not at all. "Psychology without a soul" is no longer a reproach but a truism. "The soul," as a prominent psychologist recently said, "is as dead as the dodo."

Kant represents the turning point in the history of the soul concept. From Plato to the pre-Kantian dogmatists, the current of philosophic thought through Plotinus, Augustine and Descartes brought the soul into clearer and more definite outline. It was a pure spiritual being, an entity, a real thing, constituting human personality. It was furthermore, an active being, a synthetic creative power, unifying and harmonizing the elements of knowledge. Finally it became a substance, a thinking substance, so picturesquely concrete and definite that it could even be located in a certain corner of the brain.

It is Kant who is supposed to have begun the serious unsettling of these very rigid foundations, but the net results of the Critiques is to establish the doctrine of the soul more firmly than ever. To be sure, the scholastic substantial reality of the soul, its simplicity and immortality, are beyond the ken of theoretical reason, but despite this mild skeptical innovation Kant enlarges the original, creative, synthesizing power of the mind beyond all suspicion. Human personality, indeed, belongs to the realm of "things in themselves," possessing both freedom and immortality.

While this lofty theory of the soul has been perpetuated in German and English idealism, nevertheless it is Kant's skeptical attitude as regards this subject that under the influence of modern empiricism has finally prevailed. Psychology, being a natural science, has nothing to do with Kantian *noumena*. Experience gives us a stream of thoughts, feelings and memory images, but no souls. German materialism, English associationism and American empiricism have all united in suppressing the soul. The late Professor James taught that there is not

[1] Compare Crawley, "The Idea of the Soul."

only no evidence of its existence, but it is a useless conception, its place being adequately supplied by the passing thought or feeling. "Souls," he says, "have worn out both themselves and their welcome."[2]

It would seem, therefore, to the initiate in contemporary psychology that the soul concept is obsolete or at the best obsolescent.

To the more careful student, however, this conclusion turns out to be rather hasty. Further study leads him to a series of interesting discoveries which shake his faith in his first impression. His first trouble may come when he opens Professor Eucken's recent book, "The Problem of Human Life," and reads on page 551, "Man's soul is a fact. Who can deny it? It is indeed the fundamental fact which must take precedence of all others." As he reads further in continental thought, he finds that the evanescence of the word "soul" from contemporary psychology is a phenomenon belonging largely to England and America alone. The Germans freely use the word *Seele*. His second discovery is that, while radical empiricists are carefully explaining that psychology is a natural science and as such has only to do with facts and the only facts are the passing thoughts, feelings and volitions, this attitude is only a measure of extreme caution on the part of a science which has suffered much in the past from its unhappy entanglements with metaphysics and theology and he finds that philosophers, biologists, sociologists and even these same empirical psychologists in their philosophical moods have very little hesitation in positing some theory of the soul to explain facts thrust upon them in their several fields of investigation.

His third discovery is that the psychology of the day has not so much dispensed with the soul concept as substituted merely another word for it, that word being "consciousness." He finds indeed that "consciousness" is very much in vogue. The word stares at him from every page of the text-books which studiously avoid the "soul" and the "mind." Current psychological journals abound in articles examining into the nature of consciousness, extolling its psychological, sociological and even cosmic significance. We are indeed confronted with the following interesting situation: While on the one hand, the soul has lapsed from psychological science and the psychologist is busily engaged in studying *processes* and *behavior*, on the other hand there never was a time in the history of science when from every quarter came so many assurances that consciousness is a biologic, psychologic, social and cosmic factor of the most profound importance.

Our inquiring student, therefore, will naturally ask how the concept of consciousness differs from the old concept of the soul, whether the new one is better than the old, and, if so, whether, after all, the loss of the soul is serious if something better has come to take its place.

If we turn to the standard text-books of psychology, we find that

[2] James, "A Pluralistic Universe," p. 210.

the word "consciousness" is often loosely used and has a variety of meanings. More commonly it is used in one of two meanings. It means first "the mind's awareness of its own processes,"[3] or "the immediate knowledge which the mind has of its sensations and thoughts."[4] In this sense it is a kind of subject-object consciousness and involves distinction, contrast, polarity, and may have arisen in the process of evolution in the stress and tension experienced by an organism in adjusting itself to new and adverse situations.[5] In the second sense, however, "consciousness is identified with mind, and 'conscious' with 'mental.'"[6] Mind and consciousness mean the same thing. To be conscious is just to have a mental process. Now it is in this second sense, as we are told, that the word is correctly used in psychology.[7]

It would seem then that we have merely a new *word* for the old *thing,* for it is clearly stated that the word "consciousness" when correctly used means just the same as the word "mind" and to be conscious is to have a mental or psychical experience. Consciousness is just a comprehensive word to designate all sorts of "psychical" processes, such as thoughts, feelings, volitions, impulses, pains and pleasures. Now the word "psychical" is wholly orthodox in modern psychology. It is sometimes used in a broader sense than the word "mental" and is expressly applied to any phenomenon which is subject matter of the science. But the English word "soul," corresponding to the Greek ψυχή is the noun correlative with the adjective "psychical." Consciousness, therefore, when "correctly" used, is not the consciousness indicated by the etymology of the word nor the subject-object consciousness of Locke, Dugald Stewart and historical psychology, but just a new word, a synonym for soul, having an old form and another meaning.

Now the reason why a new word was needed is simply this. The words "soul" and "mind," owing to their metaphysical and theological associations, have become obnoxious. The word "soul" in particular suggests something over and above our mere inner experiences, some "substance," which may perhaps leave the body and be "immortal." Interest in "immortality" has waned and the notion of "substance" adds nothing to our notion of psychological phenomena. Hence, owing to quite fortuitous reasons, the good old Saxon word "soul," which has indeed a much more spotless history than the word "consciousness," has been sacrificed. This perhaps was inevitable, but it is unfortunate that the new word is one having rightfully another

[3] Titchener, "A Text Book of Psychology," p. 17.

[4] Dugald Stewart, quoted by Titchener, *loc. cit.*

[5] Compare Bawden, "The Psychological Theory of Evolution," *Journal of Comparative Neurology,* Vol. XI., No. 3, p. 263.

[6] Titchener, *op. cit.,* p. 18.

[7] *Idem.*

meaning, leading to endless confusion and misunderstanding. Psychologists themselves deplore the ambiguities of the word "consciousness." "There is no philosophical term at once so popular and so devoid of standard meaning. How can a term mean anything when it is employed to connote anything and everything, including its own negation?"[8] "For the sake of clearness, terms like mind and psychosis will be substituted for 'consciousness,' owing to its ambiguity."[9] Of consciousness Avenarius says, "It would be better to give up entirely so treacherous a term."[10]

In the following illustrations of the emphasis placed upon consciousness in recent science, it should be remembered, then, that the word is used either as quite synonymous with the older words "mind" and "soul," or else, as is quite commonly the case, it is used in the sense of an indefinite, not wholly known, psychic factor of life and progress. In this latter sense the word soul, if it were permitted to use it, would be still more appropriate. The careful reader in contemporary psychological and biological science will make the further interesting discovery that the word "consciousness" is also used in the original and more proper sense, as subject-object consciousness or self-consciousness, and that it is usually so used by those writers who are engaged in showing that consciousness is an evolutionary product of life and organization, while, on the other hand, those now numerous writers and investigators who believe that consciousness is a primitive datum or deep underlying force of life, organization and progress, use the word in one of the other two senses just mentioned.

Let us take, then, a few illustrations of the emphasis which recent science is putting upon consciousness as a world factor of primary importance. Let it be borne in mind that until recently there were few outside the ranks of idealistic philosophers to dispute the prevalent belief that mechanical laws are sufficient to account for every phase of human life, including mental and moral phenomena; that at certain stages of organic evolution consciousness appears as a kind of by-product and has no agency in the life drama itself, and that it is not necessary to take any causal account of it in explaining life in its physiological, psychological or social aspects. With this view compare that of many representative present-day psychologists who hold that consciousness, although itself perhaps a product of evolution, has become a factor in evolution of the very first importance, changing not only the very face of the earth, but changing the direction of evolution itself. One writer says:

[8] Perry, "Conceptions and Misconceptions of Consciousness," *Psychological Review*, Vol. 11, p. 282.

[9] Crawley, "The Idea of the Soul," p. 58.

[10] "Am besten wäre man gäbe einen so verfänglichen Ausdruck ganz auf." Quoted by W. T. Bush, *Journ. Phil., Psych. and Sci. Meth.*, Vol. II., p. 561.

I believe we need to work further on this problem of evolution until we see that in its consummation organic evolution passes into a form of adjustment in which the inner world with its conscious pattern for changes in the outer world is more important than any form of objective selection which can be discovered. . . . Consciousness is the essential fact in human life, as I have attempted to show. What man does with his environment depends upon consciousness. That phase of individuality which is important enough to change the type of evolution certainly can not be described as non-existent or as merely resolvable into its elements.[11]

Some day the historian of thought will write it down as one of the curious fallacies of immature science that certain physiologists, biologists and even psychologists were satisfied to call their own personalities mere by-products, without essential significance in the world, just because they did not find consciousness capable of description in the regular scientific formulas adapted for the discussion and explanation of external reality. One hardly knows how to find phrases in which to answer those who hold consciousness to be less real and potent than physical forces.[12]

These writers refuse to limit the idea of causality in such a way as to exclude the conspicuous fact that the mind is a veritable cause. By its peculiar and exclusive power of ideal reconstruction of experience, it becomes a tremendous new force in the world, bending material forces to its will, first picturing then realizing ever higher marks in science, art, literature, justice and the progress of civilization in general. Consciousness certainly is potent, and if potent, then, according to pragmatism, true and real.

Thus far, then, it begins to appear that, even granting that consciousness may be a product of evolution, nevertheless its potency and hence its reality might become the ground for what may be called a re-discovery of the soul. But there is a tendency not only to recognize the reality and potency of consciousness, but to carry it farther and farther back in the evolutionary process, if not to make it a primitive datum. The old "orthodox" descent, starting with chance variation and natural selection and coming down through simple irritability and sensory-motor reflexes, till finally consciousness is evolved, no longer satisfies either psychologists or biologists. Many believe that all so-called reflex acts, including instincts, were once conscious acts. The fact that conscious actions tend to become automatic might, however, easily be misunderstood. It does not point to any displacement or impoverishment of consciousness. Such apparent displacement "is for the sake of its own inherent ends, being the *conditio sine quâ non*, of its further extension and enrichment."[13] Human development does

[11] C. H. Judd, "Evolution and Consciousness," *Psychological Review*, Vol. XVII., 2, pp. 90, 93.

[12] C. H. Judd, "Psychology," p. 62. Compare Edward M. Weyer, "A Unit Conception of Consciousness," *Psychological Review*, XVII., 5, p. 318.

[13] Norman Smith, *Philosophical Review*, Vol. XVII., p. 334, reviewing Mitchell's "Structure and Growth of the Mind."

not seem to be in the direction of instincts exhibited by bees and ants, but in quite another, namely, that of self-reflective intelligence.[14]

Something, then, more or less of a psychical nature, call it soul, call it consciousness, call it sensibility, call it vital impulse or vital force, or call it merely a psychic factor of progress, has been a primary factor in organic evolution. "Life has preceded organization" and "consciousness was coincident with the dawn of life." It has been a kind of "*primum mobile*" of organic structure. Something like "effort" has preceded upward changes.[15] Consciousness is not a function of organization and is not an epiphenomenon. It is a bionomic factor of the utmost importance. It is of the highest use in adapting organism to environment. It changes the direction of energy. It intervenes between sensation and reaction in the realization of ends. "A frank unbiased study of consciousness must convince every biologist that it is one of the fundamental phenomena of at least animal life, if not, as is quite possible, of all life." "Consciousness is a conspicuous, a commanding factor of adjustment in animals."[16]

Whether consciousness is thought of as a form of energy comparable with heat and electricity,[17] or as an independent dimension of reality,[18] or as some original and primary correlative of energy,[19] nevertheless it is certain that it is a reality, a potency, a factor second to none other, physical or metaphysical.

Even the biological laboratory is offering a suggestive support to the soul hypothesis. If one chooses to accept the theory, as old as the history of thought, that something of a psychical nature bridges the gap, still unspanned by natural science, between the organic and the inorganic, his belief gains new and unexpected support from recent biological studies. So much scorn has been cast upon the theory of vitalism that its recent renewal by a whole school of able German biologists is exceedingly significant. Driesch bases his vitalistic conclusions upon the most careful and long-continued laboratory researches. He discards the machine theory of the origin of life.

> No kind of causality based upon the constellations of single physical and chemical acts can account for organic individual development; this development is not to be explained by any hypothesis about configuration of physical and chemical agents. . . . Life, at least morphogenesis, is not a specialized arrange-

[14] Compare Bergson, "L'evolution créatrice," Chapitre II.

[15] Cope, "Primary Factors of Organic Evolution," p. 508 ff.

[16] Chas. S. Minot, "The Problem of Consciousness in its Biological Aspects," *Science*, N. S., Vol. XVI., No. 392, pp. 17, 19.

[17] Compare Ostwald, *Monist*, Vol. 17, p. 514, and Grunewald, "Zur Energetik des Lebens," *Annalen der Naturphilosophie*, IX., 237.

[18] Compare Boodin, "Consciousness and Reality," *Journ. Phil., Psych. and Sci. Meth.*, Vol. V., No. 7, p. 173.

[19] Compare Minot, *loc. cit.*

ment of inorganic events; biology, therefore, is not applied physics and chemistry: life is something apart, and biology is an independent science.[20]

By giving to this elemental directive factor the name "entelechy" and by applying to it in its formative aspect the further name "psychoid," Driesch implies and indeed repeatedly affirms not only its reality, but its analogy with what we call the psychical.

Nägeli's "Vervollkomnungsprinzip," or inherent factor tending towards progress in evolution, Noll's "Morphæsthesia," or feeling for form which plants are said to possess, Korschinsky's "special tendency to advance," Cope's "archæsthetism," "the inherent driving force," "the inner law of development," "the inner directive force," of other biologists,[21] all have a strangely psychological sound. It is of course true that these positions are vigorously contested by biologists of the orthodox schools, who speak of the "recrudescence" of vitalism. But protests such as the above against the sufficiency of mechanical laws to account for progress in evolution are becoming so many and from such high sources that no psychologist who would postulate a psychic factor of progress, constituting, it may be, the soul of plants, animals and man, need any longer hesitate for fear of censure from the biological camp.

But if vitalism is objectionable, it should be remembered that the choice is by no means between that and the sufficiency of the Darwinian theory of chance variation and natural selection. The number of biologists who accept neither of these solutions of the evolutionary problem is of course very great. If one accepts, for instance, the mutation theory of de Vries, it should be remembered that the difficulties of explaining the *cause* of the adaptive variations upon which Darwinism depends are greatly increased in explaining the cause of the sudden and rapid mutations in the system of de Vries. In general one may say that the belief in orthogenesis, or development in certain definite directions, has to a considerable extent superseded Darwin's theory of development, and with the increasing belief in orthogenesis comes an increasing demand for some yet unknown factor determining the direction of development, and while there are many theories proposed to account for such development without the introduction of any teleological or psychic factor, nevertheless it appears that those who wish to renew the time-honored hypothesis of some such factor are now heard with increasing respect.

From facts such as these we see not only that many workers in science are busily engaged in the search for the soul, but also that the prospects are reasonably good that they will find it.

But let us return to the psychologists. Another aspect of the tend-

[20] Driesch, "The Science and Philosophy of the Organism," 1907, p. 142. Compare G. Wolff, "Beiträge zur Kritik der Darwin'schen Lehre."

[21] See Kellogg, "Darwinism To-day," pp. 277, 278.

ency to glorify the mind and to give to it, or to some part of it, or to something like it, a leading rôle on the stage of events is seen in the voluntaristic movement. The voluntarists do not necessarily hold to any old-fashioned notions of the will as real. The tendency in voluntarism is a part of the general tendency to believe that processes are more real than things. Our volitions, therefore, being obviously processes, movements, springs, are better types of psychical reality than sensations or ideas. So on every side we find emphasis laid upon will, impulse, instinct, inner activity, mental initiative and attention. "Inner activity" is spoken of in the case of the lowest animal organisms and even of plants. In studying animal behavior, we learn that the earliest movements are not mere reflexes, but a series of "trial movements of the most diverse character and including at times practically all the movements of which the animal is capable."[22] Likewise the reflex mechanical theory fails to account for the "tropisms" of plants. Although few biologists would explain the "tropisms," or perhaps even the "trial" movements of the microorganisms as psychical, nevertheless it is admitted that they are forms of inner activity and not reflexes, and it is hard for psychologists not to associate them with such human phenomena as attention, impulse and initiative. The suggestive term "restlessness" has been used to characterize these simple forms of self-activity.[23] Something like an eternal restlessness seems to be present in every form of living matter from the microorganism with its incessant "trial" movements to the adult human being with his exhaustless aspirations. It manifests itself in the variations and mutations of plants and animals, in the "try, try again" movements of the creeping child, in the play of youth,[24] in the inner stirrings, passionate longings and ceaseless activities of the adolescent, and in the inventions, explorations, ambition and progress of the mature man of culture. Despite every effort of naturalism to explain the power of voluntary and sustained attention, the apparent freedom of the will, and the art impulse, there remains in these phenomena an unexplained residue which apparently depends upon this inherent principle of self-activity.

The term "restlessness," however, suggestive as it may be, does not quite rightfully express the character of this profound principle of inner activity which eludes all scientific analysis. It is something more than restlessness and something less than aspiration. All attempts to account for progress, whether cosmic or human, without the assumption of some such deep psychic factor, have failed. There is apparently in man, as in nature, a *spring* of progress, an upward and

[22] Jennings, "Behavior of the Lower Organisms," p. 280.
[23] Royce, "Outlines of Psychology," Chaps. VII. and XIII.
[24] *Idem*, p. 319.

forward impulse, an effort, a ceaseless striving, a will to produce always a more perfect form, a better function. It is this tropic, restless, aspiring force, this psychic factor of progress, that prompts us evermore to invent a new way, a shorter cut, a better method, and leads to the steady and inevitable raising of moral and political standards. To speak of this factor as a "force" or "energy" is merely to use a category taken from material science. To say that it is "teleological" and works towards "ideals" is to interpret it in terms of narrow human experience. It matters little what we call it, but if we call it "mind" or "soul," it suggests no longer a "substance," no static quantity, nor yet just the sum total of our conscious life—but rather a sort of bubbling spring, a profound source, from which upwells the entire organic world, culminating now in the whole mass of human achievement and aspiring to some ever higher conscious or unconscious goal.

PROGRESS IN CONTROL OF PLANT DISEASES

By Dr. F. L. STEVENS

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PLANTS are subject to disease. As in the human being these diseases decrease vigor and productiveness of the organism or cause death. An attack upon valuable plant products such as ripe fruit, tubers and root crops, and mature timber may result in depreciation in value or even entire loss of the product. The rot of apples upon the tree or in the bin, the common blue mold seen upon lemons and oranges, the wide-spread blight of pear and apple twigs (Fig. 1) are familiar examples of plant disease.

In the early years of American history these afflictions were regarded as natural and inevitable, but during the last three or four decades scientific study has shown that rots, blights, molds, mildews, rusts, smuts, etc., are true diseases; that they do not constitute any part of the normal life stages of the plant affected. That they are caused by living parasites and, moreover, that they are often preventable.

Plant diseases have increased largely in number and destructiveness during recent years. This is due in part to the migration of disease from county to county and state to state; in part to the cultivation of weak or susceptible varieties and in part to long continued cropping in a given region, thus affording opportunity for the plant pests, which may at first have been weak and unimportant, to become thoroughly established and aggressive.

The asparagus rust, which has in some states nearly prohibited asparagus culture, offers an excellent example of migration in its progressive westward march across our continent. This invasion seems to have occupied the years between 1896 and 1902 since the rust was first noted at New Jersey in 1896, South Carolina 1897, Michigan 1898, Illinois 1899, Dakota, Nebraska and Texas 1900, California 1901 or 1902.

The destructive pear blight, our worst pear disease, made a similar journey, starting from the neighborhood of the Hudson valley, near the beginning of the last century, reached the Rockies sometime after 1886 and arrived in California about 1895.

Diseases have come to America from Europe. Grape anthracnose, cabbage club root, potato wart (Fig. 2), are noteworthy examples; sim-

ilarly, serious American plant diseases such as potato blight, grape black rot, grape downy mildew and powdery mildew have made the European tour or even the world tour "personally conducted" under some unwitting guides.

The chestnut bark disease (Fig. 3) illustrates well the rapid and destructive invasion that is possible in case of new diseases. First noted in 1904 by Murrill in New York, and now well known in New York, New Jersey, Delaware, Connecticut, Rhode Island, Maryland and Virginia, it is rapidly spreading in every direction (Fig. 4). In Brooklyn 16,695 trees were killed on 350 acres, and the loss in and about New York city is placed at five to ten million dollars. The chinquepin and chestnut alone are susceptible. The attack is made upon the bark through wounds, but twigs and leaves are not directly affected. From the point of attack the disease spreads in all directions until the diseased parts meet on the opposite side of the branch, thus girdling the twig and killing it.

FIG. 1. PEAR BLIGHT, healthy and diseased twigs.

Sometimes it happens that a newly introduced disease causes much loss in its first years and later sinks to comparative insignificance. Such was the history of the carnation rust which about 1892 caused the loss of entire houses of plants, but which in a few years spent its force until it is now regarded as a disease of no unusual menace. In other instances imported diseases continually remain serious, as have the numerous grape diseases introduced into Europe from America and from Europe into America.

FIG. 2. A POTATO HALF DESTROYED BY "WART DISEASE"; the large "warty" outgrowth is soft and rapidly decaying.

The diseases mentioned in Diagram I. are nearly all of great destructiveness. The potato blight is that which caused the famous potato famine in Ireland in 1845, in which year it swept Great Britain as well as much of Europe and America with a

FIG. 3. LARGE CHESTNUT TREES KILLED BY THE BARK DISEASE.

wave of disease. It to-day causes loss estimated at $36,000,000 annually in the United States. New York alone has incurred a loss of $10,000,000 in one year.

The asparagus rust prohibited successful asparagus culture in several states and threatened that industry in California, where the crop occupies yearly over 7,000 acres of land, until means of control were devised by scientific men. The rice smut was recognized in its

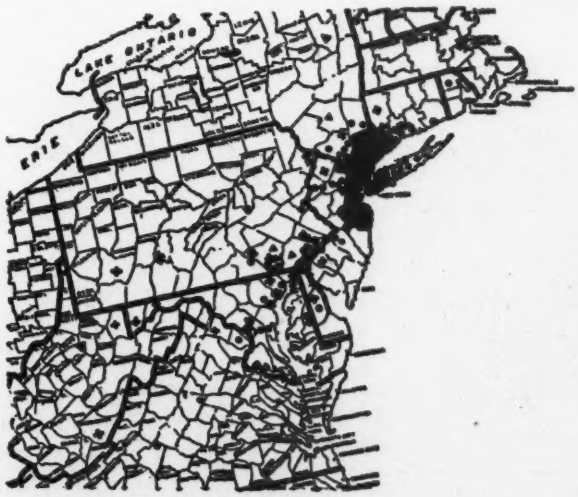

FIG. 4. MAP SHOWING THE DISTRIBUTION OF THE CHESTNUT BARK DISEASE. Black shows area of severe infection; round dots, presence of disease prior to 1909; + indicates the spread of the disease during 1909. After Metcalf.

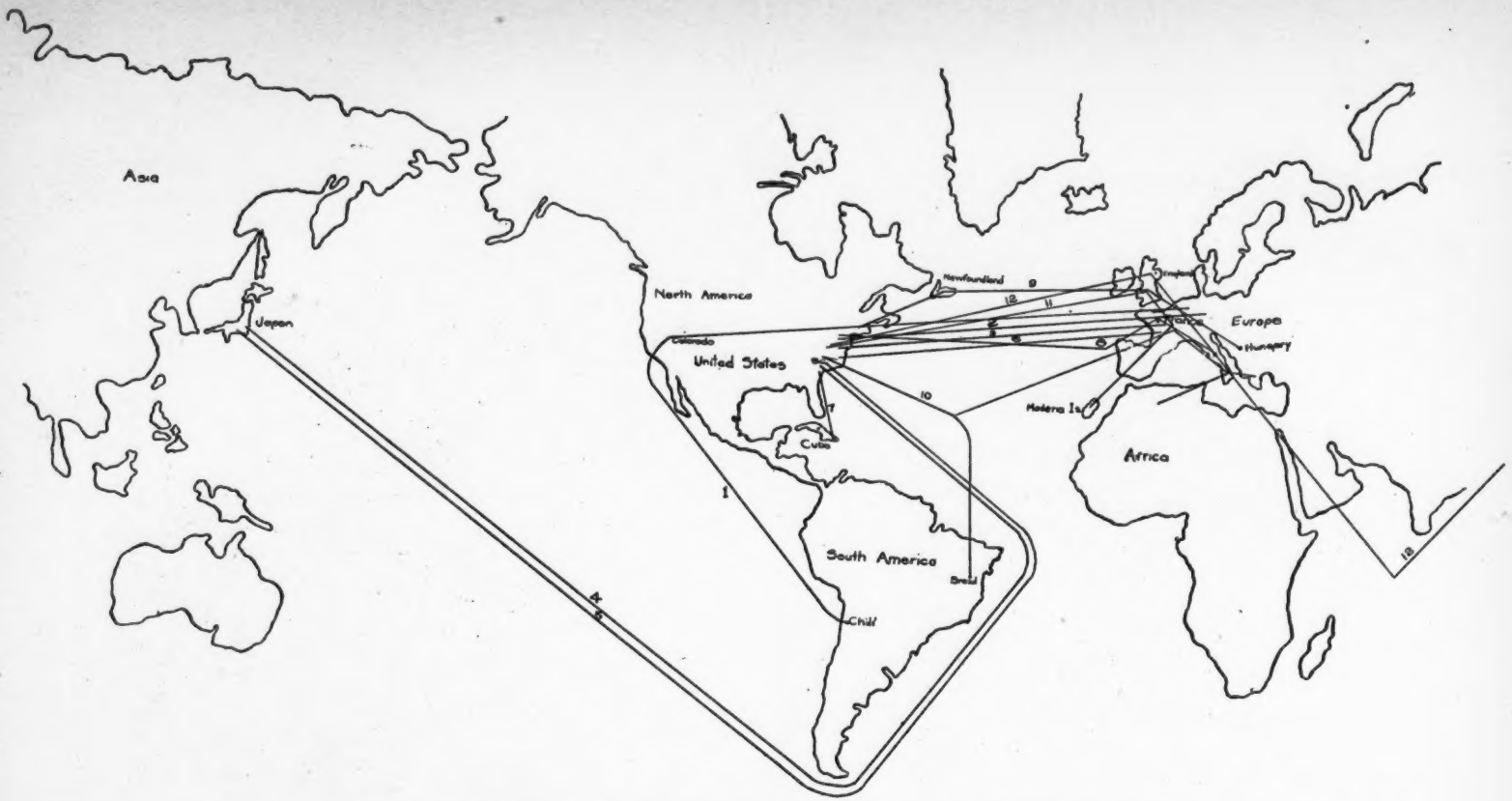

DIAGRAM 1. ILLUSTRATING THE INTER-CONTINENTAL MIGRATION OF PLANT DISEASES.

No. 1, potato blight: Chili-Colorado-Europe. No. 2, asparagus rust: Europe, 1805; New Jersey, 1896, South Carolina, 1897; Michigan, 1898; Illinois, 1899; Dakota, Nebraska and Texas, 1900; California, 1901. No. 3, potato cercosporose: Europe, 1854; United States, 1903. No. 4, rice smut: Japan-South Carolina, 1898. No. 5, sorghum smut: Japan-United States, 1884. No. 6, grape anthracnose: Europe-America, 1880, or earlier, now widespread. No. 7, cucumber downy mildew: Cuba, 1868; United States, 1889. No. 8, grape black rot: North America, early; France, 1885; Italy and the Caucasus, 1898. No. 9, potato wart: Hungary, 1896; England, 1900; Newfoundland, 1909; Boston and New York, 1910. No. 10, grape downy mildew: America early; France, 1873; The Rhineland, Savoy and Italy, 1879; The Tyrol and Algiers, 1880; Portugal and Greece, 1881; Alsace, 1882; the Caucasus 1887; Brazil, 1890. Now known in all countries except Australia. No. 11, grape powdery mildew: United States, early; England, 1845; Belgium and France, 1848; all Europe, 1849; Madeira, 1852. Known everywhere now. No. 12, chrysanthemum rust: Japan-England, 1895; America, 1896.

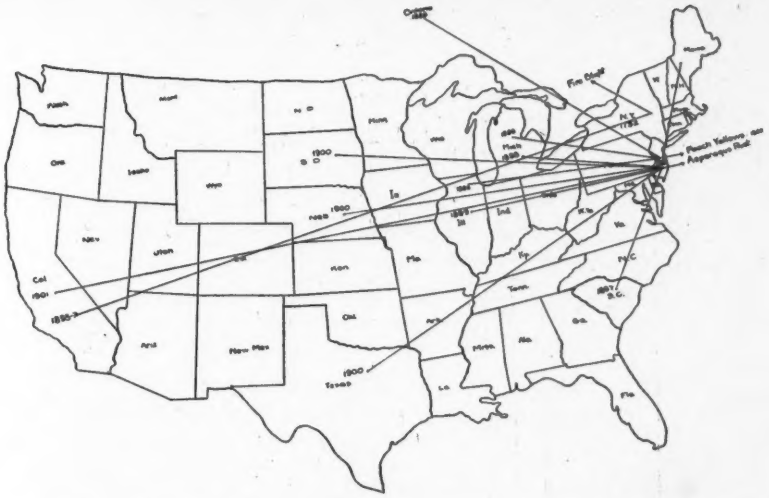

DIAGRAM 2. SHOWING INTER-STATE MIGRATION OF SOME IMPORTANT DISEASES. 1, asparagus rust: New Jersey, 1896; South Carolina, 1897; Michigan, 1898; Illinois, 1899; Dakota, Nebraska, Texas, 1900; California, 1901. 2, fire blight: the Hudson, 1792; California, 1895–7, 3, peach yellows: Philadelphia, 1806; Ontario, Michigan, Illinois, Maine, 1886.

first encroachment in South Carolina and an agressive campaign against it with remedies which had recently proved efficient against smuts of other cereals checked it and completely subjugated it, so that it is no longer known in the Palmetto State. The cucumber mildew, which causes blanched spots on the leaves and often entire loss of crop, has rendered unprofitable the culture of cucumbers and cantaloupes in many sections. The two grape mildews are notorious in their destructiveness and have driven vineyardists to large expense in spraying or sulphuring.

Perhaps the most striking importation is that of the potato wart. This disease causes large unsightly knotty excrescences on the potato, rendering them worthless. It was first reported in England in 1902, found its way to Newfoundland, and it is known that two consignments of Newfoundland potatoes, probably infected, were shipped last year, one to New York, one to Boston. The spread of this disease in our states is an event to be predicted with confidence, especially as many sections of the country depend upon New England for their seed potatoes.

The large increase in aggressiveness of plant diseases has been met by a campaign of increased knowledge leading to new modes of subjugation. Though a few plant diseases are mentioned in early writings, (II. Chronicles 6–28, Shakespear's King Lear, III., Sc. 4; I. Kings 8–37; Moses 28, 22), the real significance of their presence, their nature and causes may be said to have been first recognized between the

Belgium and France, 1845; all Europe, 1845; Madeira, 1852. Known everywhere now. No. 12, chrysanthemum rust: Japan-England, 1895; America, 1896.

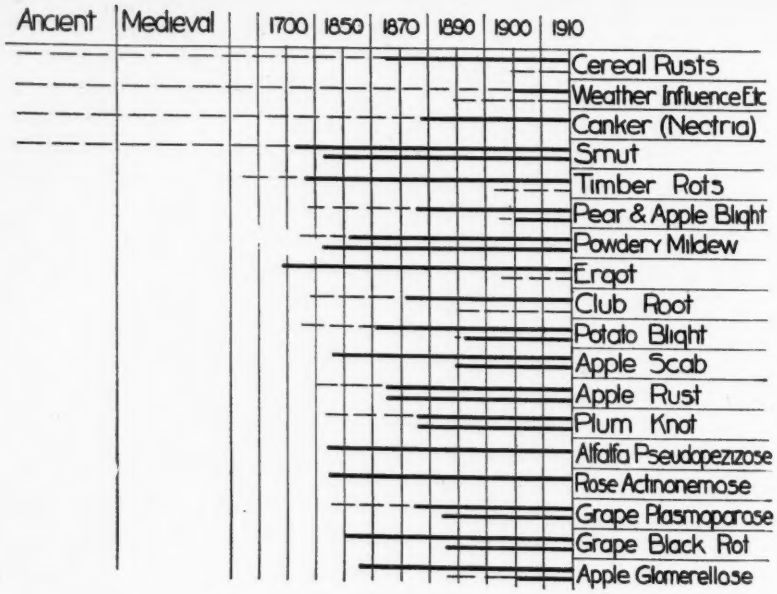

TABLE I

TABLE I (*Continued*)

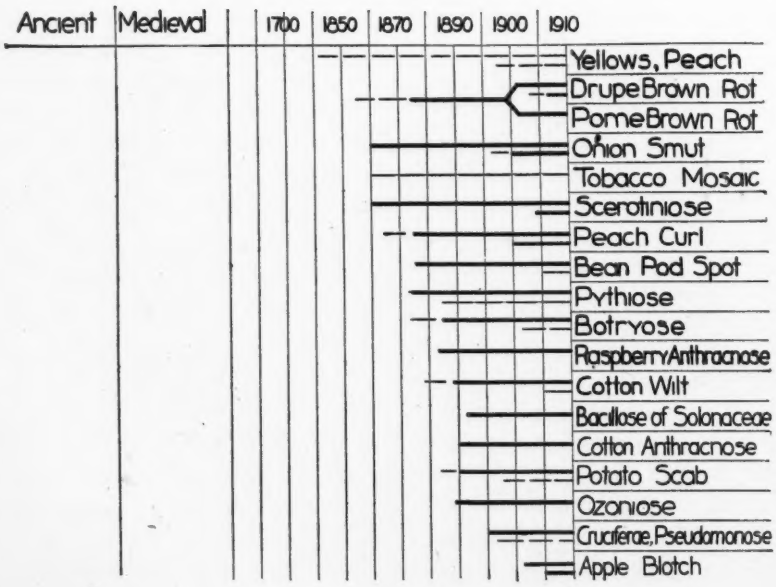

TABLE I. SHOWING ADVANCE IN KNOWLEDGE REGARDING SOME OF THE CHIEF PLANT DISEASES. The broken upper line indicates vague or indefinite knowledge; the solid line definite knowledge. The lower broken line indicates partial but unsatisfactory knowledge concerning treatment; the solid line the possession of facts sufficient for satisfactory treatment.

years 1846 and 1864, notwithstanding the fact that the first sulphur treatment for powdery mildew was recommended in 1821 and the first seed treatment for smuts was discussed in 1807.

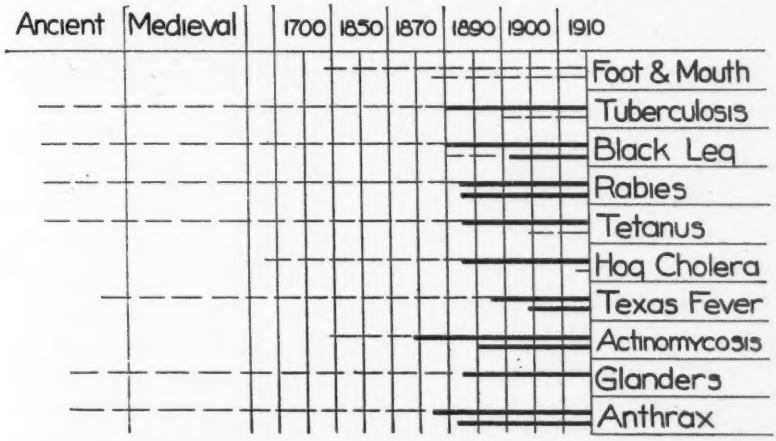

TABLE II. SHOWING ADVANCE IN KNOWLEDGE REGARDING SOME OF THE CHIEF DISEASES OF DOMESTIC ANIMALS. The broken upper line indicates vague or indefinite knowledge; the solid line definite knowledge. The lower broken line indicates partial but unsatisfactory knowledge concerning treatment; the solid line the possession of facts sufficient for satisfactory treatment.

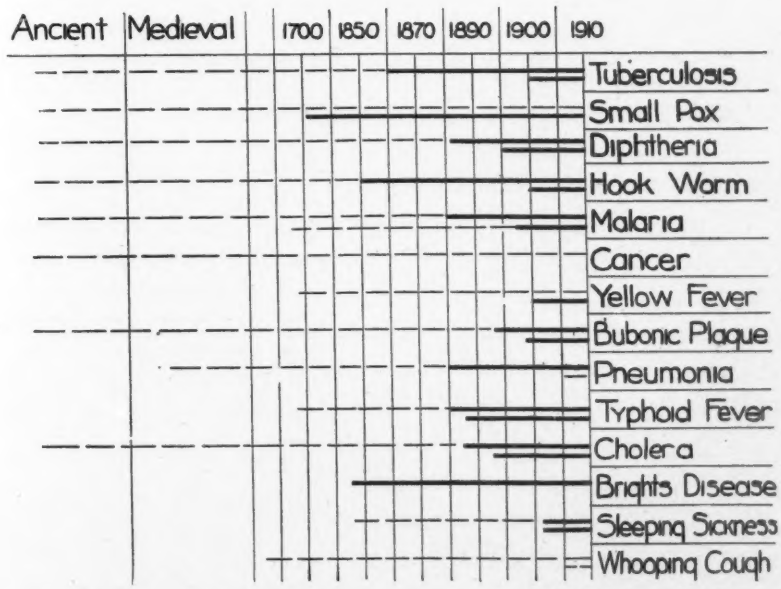

TABLE III. SHOWING ADVANCE IN KNOWLEDGE REGARDING SOME OF THE CHIEF HUMAN DISEASES. The broken upper line indicates vague or indefinite knowledge; the solid line definite knowledge. The lower broken line indicates partial but unsatisfactory knowledge concerning treatment; the solid line the possession of facts sufficient for satisfactory treatment.

The most important advance in prophylactic procedure came with the introduction of the Bordeaux mixture, a compound of lime, bluestone and water, by Millardet in 1885. Since that date the battle has waged fiercely with successive conquests for plant pathology. Now many of the most important diseases are well understood and many successful modes of treatment have been devised.

Some of these with their most significant dates are represented in Table I.

During the seventies there were only two or three investigators in plant pathology in America. This number rapidly increased until between 1888 and 1900 over 4,000 papers upon this subject appeared. Only a few dozen economic plant diseases had been even cursorily described prior to 1880, while to-day a total of over 500, more than 250 of them serious, have been investigated. Countless diseases of wild plants also are now known more or less completely.

To enable comparison of the real advance made in plant pathology with the advances made in the sister fields of veterinary medicine and human medicine, two tables are given summarizing the history of these two fields as regards a few of the most important diseases (tables II. and III.).

That plant pathology has made such a relatively good showing notwithstanding her tardy start is due to the late influence of the germ theory of disease in all of these fields.

With the continual increase of plant diseases in both number and aggressiveness every effort of the plant pathologist will be required to increase the efficiency of treatment. So also is there great need of a public opinion favoring rational plant sanitation. The chief diseases now prevalent as well as those which are liable to invade any section in the near future should be known to all plant producers. Especially needed are laws properly enforced to restrict the migration of diseases.

THE SERVICES AND REWARDS OF THE OLD GREEK VOLUNTEER

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RECENTLY ACTING PROFESSOR OF GREEK AT LEHIGH UNIVERSITY AND SOMETIME G. A. R. FELLOW AT BROWN UNIVERSITY

FROM Athens to America; from Marathon, Salamis and Chæronea to Bunker Hill, Gettysburg and Manila Bay, greatness and gratitude have been inseparable terms in national glory. From the earliest history of soldiery down to our day, martial renown and even long lease of national life have been won by those nations only which asked the greatest sacrifice and bestowed the greatest honors and rewards upon their citizen-soldiers.

The prestige of Roman arms has gone up and down the world, but the people of Greece showed a devotion to their warrior braves almost unequalled in the annals of civilization. We are apt to feel that the victories of Greece were those of the brain and not those of the sword, and, in her signal influence on posterity, little Greece doubtless won her greatest triumph in the realm of the intellect; for the chisel of Phidias, the brush of Apelles, the logic of Socrates, the speeches of Demosthenes, the tragedies of Æschylus and the inspired verses of Homer have become the legacy and inspiration of the nations. But the preservation, growth and dissemination of these treasures necessitated a perpetual war.

Greece, fighting for Europe and European civilization, met Asia in the longest defensive warfare known in history, and though all the nations constituting the Greek people were no larger than the state of West Virginia, they fought a winning fight with the countless hordes and uncounted treasure of the Persian Empire. From Agamemnon to Alexander, the conflict was felt to be on at every moment of their national life. The "Iliad" of Homer—call it fable or tradition, as you please—reveals the Greeks, a thousand years before our era, waging the Ten Years' War at Troy. Five centuries later the early historical record finds Miltiades victor at Marathon, where Europe worsted Asia and saved the world for progress. Though too early for reliable history, we may safely say that the five centuries between Troy and Marathon could not have been free from Asiatic transgression. Ten years of preparation but repeat the victory of Marathon in the naval fight at Salamis and Europe drives back Asia, Athens wins the leadership of Greece and, uniting the different states in a league against

Persia, founds the so-called Athenian Empire. Revolution and interstate wars were rife, but were all for the one object—the leadership of Greece against Asia. In every war up to the time of Philip of Macedon, Persian gold and Asiatic sympathy had to be reckoned with. Greek unity was never attained and apparently hardly desired, but Greek supremacy was both desired and won. Greece was victor in the seven-century contest, and the gloomy conservatism of Asia yielded to the vitalizing progressiveness of Greece in the policy of Europe; the home triumphed over the harem; hierarchal dictation and monarch's whims gave way to national law on this side of the Ægean; and individual freedom was still possible.

Throughout military history, the volunteer has always fought the most momentous battles, and when the old Greek citizen-soldier drove back Asia he not only saved his people, but fixed the civilization of a continent. Great as was the warrior's service to his race, correspondingly liberal were the honors and awards bestowed by a grateful nation. By special decree of the Athenian Assembly—that national "town-meeting"—the soldier of conspicuous prowess was voted exemption from the financial exactions of state, which not only anticipated the exemption from taxes of estates up to $1,000 of our union soldiers—so patriotically granted by many of our states to-day—but extended further and covered all fiscal contributions imposed by government in either peace or war. Seats of honor at the national theater and great games were awarded; memorial statues were erected; and crowns for bravery, much like the Victoria Cross and Congressional medal of to-day, decorated the heroes of the Grand Army of the Republic of Athens.

And too, that martial state which bore the brave little band of Leonidas and the Spartan mother could hardly fail to do honor to her noble sons who fell fighting for their hearths and shrines. Lycurgus, the Spartan lawgiver, Plutarch tells us, ordered that none but soldiers who lost their lives in battle should have their names, origin and deeds inscribed on their tombs. With green boughs they were laid away and honored with an oration by their fellow-countrymen; but the champions of the host and those Spartan braves who were considered complete warriors were buried in their red coats, with their arms affixed upon their tombs.

How deeply the stern martial virtues of the old Spartan life were engraved on the hearts of her people the mother's treatment of her soldier-boy clearly reveals. It was customary for the Spartan matrons, after an engagement near home, to examine the dead bodies of their sons. Those who received more wounds behind than in front were carried away secretly or left in the common heap; but those who had the greatest number of wounds in their breasts were carried off with

joy and triumph to be buried with their ancestors, to whom was offered a worship second only to that paid the gods. The shield was used as a bier on which the dead were carried home from the battle-field and from this custom tradition has handed down the famous appeal of the Spartan mother to her son, on his departure to the conflict, girt with this defensive arm: "Bring it with you or be brought on it," or better still "It or upon it."[1]

Though the Spartans never wrote the history of their wars, fragments of their war-bard, Tyrtæus, singer of the Marseillaise of Greece, seven centuries before our era, ring with tones of Dorian loyalty and scornful pity for the recreant in battle:

> Up! Youths of the Spartan nobles,
> Ye citizen sons of the elders!
> With the left hold out your targes,
> And fling your spears with boldness.
> Spare not your lives. To spare them
> Was never known in Sparta.
>
> —ALLINSON.

> How glorious fall the valiant, sword in hand,
> In front of battle for their native land!
> But oh! what ills await the wretch that yields,
> A recreant outcast from his country's fields!
> The mother whom he loves shall quit her home,
> An aged father at his side shall roam;
> His little ones shall weeping with him go,
> And a young wife participate his woe;
> While scorned and scowled upon by every face
> They pine for food and beg from place to place.
>
> . . . . . .
>
> But we will combat for our father's land
> And we will drain the life-blood where we stand
> To save our children.
>
> —SYMONDS.

A beautiful custom at Athens by which national gratitude was paid to the memory of her noble sons who fell in battle, was the solemn interment of their ashes in a public tomb in the National Cemetery, situated in the most beautiful portion of the outskirts, near the "Double Gate." This public distinction of the men who freely and deliberately offered up their lives on the field for the freedom and renown of their country and the maintenance of her constitution was considered by the nation a sacred duty not only of gratitude, but of justice. She therefore made provision that the memory of such citizens be fittingly celebrated by orations and perpetuated by monuments. Whether this custom originated at Athens with Solon, the sixth-century lawgiver—as seems very probable—or shortly after the Persian Wars (478 B.C.), it was, beyond question, the most laudable and val-

[1] Plutarch, "Apothegm."

uable, in national influence, of all the excellent customs which the wisest people of antiquity sacredly guarded in its institutions. The tribute paid to the dead by a public acknowledgment of their services; the sympathetic bearing by the body-politic of those losses which burden individual families; the consolation offered by the orator, appointed by the state and speaking to the fathers and mothers, wives and children of the dead soldiers; and the general uplifting of the soul above the sorrows of the mourner to the holy, patriotic joys of the nation's heart, inspired crowds of her citizens with the spirit of deliberate martyrdom and gained for the first republic in the world that heroic devotion that other forms of government can but feebly understand.

The prelude to the splendid funeral oration of Pericles, political master of Athens, gives an interesting description of the ceremonies attending military funerals in the Peloponnesian War (431 B.C.).

> The bones of the dead were laid out under an awning, two days before the funeral,[2] and each man brought to his own relative whatever funeral offering he pleased. On the day of the funeral, coffins of cypress-wood were carried in wagons, one for each tribe—ten in number—and in these were laid the bones of each man, according to the tribe to which he belonged. One empty bier was carried, spread with a cloth, in honor of the missing whose bodies could not be found for burial. Any one who wished, whether citizen or stranger, joined in the procession and the women were present at the funeral to make "lamentation." The remains were then placed in the public tomb which was in the fairest suburb of the city—the Ceramicus—in which they always buried the warriors with the single exception of those who fell at Marathon, and to these, conspicuous for their valor, they gave burial on the very spot. After they had laid them in the ground, a man of high repute and eminent position, chosen by the nation, spoke a fitting eulogy over them. After that the people went home. Thus they buried them and through the whole of the war, on every occasion, they observed the custom.[3]

The oration was repeated on the anniversary of the solemnity and, as Plato said in the Menexenus, "the nation never ceased honoring the dead every year, celebrating in public the rites proper to each and all; and in addition to this, holding gymnastic and equestrian festivals and musical festivals of every sort." Thus did all the different departments of national, religious and artistic life contribute to the glorification of the Memorial Day of the old Athenian volunteer.

A brief analysis of the military panegyric at Athens, together with a few extracts from her most celebrated funeral orations may be of value both as a mirror of the customs of the day and as an expression of the grateful sympathy of the nation's heart. As Bekker has said in his "Demosthenes as Statesman and Orator," "the subject was always the same—praise of the dead soldiers, mourning of their country for her

[2] Private funerals often took place the next day after the decease, cf. Demosthenes, Or. 43, Sec. 62, in a law attributed to Solon. Note similar custom in the gulf states of our country.

[3] Thucydides, Bk. 2, Sec. 34 seq.

loss and consolation for the nearest relatives. It was the duty of the orator, on such occasions, to celebrate the deeds of their ancestors, back to the mythical period and to connect them with the recent glorious achievements of the honored dead. Prescribed usage dictated the nature of the consolation offered—the renown of the departed; the happy lot of the deceased from a consciousness of duty well done on earth; the care the state will take of their families; and finally an appeal to the survivors to submit to their fate and prove themselves worthy of the example set by the fallen heroes. The introduction and conclusion of all the extant funeral speeches are practically alike, beginning with the declaration that the duty imposed on the orator surpasses his strength, which, at the most, can only equal the efforts of previous speakers; and ends with the words 'now go back to your homes after you have bewailed the dead according to custom.'" But after all, it is not hard to justify or difficult to approve the century-tested, ritualistic formality of the old Athenian funeral oration; for a deep feeling of sincere grief must be the dominant note in a funeral speech. Novel thought and fervid rhetoric could bring no comfort to the afflicted, whose hearts, rent with sorrow, respond only to that calm and beautiful language in which the poet has voiced our common and most agonizing woes. A master's task the poet-orator was forced to face!

Of the six funeral orations that have come down to us, two—sometimes assigned to Demosthenes and Lysias—are probably the work of other hands; two others—imaginary speeches but among the greatest specimens of their kind in the world's literature—are the stylistic and patriotic models of Plato in the "Menexenus," and the grand funeral speech Thucydides, the historian, has put into the mouth of the eloquent Pericles; the other two—fragments of funeral orations by Gorgias, the celebrated Sicilian orator and father of rhetoric, and Hypereides, the master-panegyrist of the ancient world—were actually delivered in honor of Athenians who fell in battle.

Pericles closes his celebrated memorial to the dead soldiers, substantially, as follows:

And it behooves you who survive to pray for a more steadfast purpose and to demand of yourselves that you have no less daring spirit against the enemy than they, considering the advantage of that courage, in no merely rhetorical way but by actually keeping before your eyes the daily increasing power of your country and by becoming lovers in her service; and when she appears to you to be really great, by taking seriously to heart the fact that daring men and men who knew their duty, showing too a sense of pride in their actions, secured this greatness; and when they failed in any attempt they did not for that reason think of depriving their country of their valor but made together the noblest contribution in her behalf.

Sacrificing their lives for the common good, they gained each one their proper meed of never-dying praise and a most illustrious sepulchre—I speak not of that in which their bones lie moldering but of that in which their fame

is enshrined, eternally remembered on every recurring occasion that calls for speech or action. The whole earth is the sepulchre of famous men and not only is the epitaph on the funeral column in their home-land a proof of this, but there abides with all men, even in foreign lands, an unwritten memorial in the heart rather than on the external monument.

Now, from this day, taking these men for your models, judging freedom the only happiness and valor the only freedom, do not neglect the perils of war; for it is not the wretched, despairing of the good things of life, who may more properly be reckless but rather those for whom a change for the worse is the risk they must run while life lasts. They experience the greatest difference if any disaster befall the state. Cowardice and disgrace combined are more painful to a man of spirit than death, insensibly received and attended by courage and hope of the common good.

Wherefore I will not lament with the parents of our dead, who may be present here, but will offer only words of comfort. And they know that they are reared 'midst shifting vicissitudes of fortune. But happiness is gained only when men receive for their lot a most honorable death—as these heroes now—or sorrow like unto your sorrow and their life was finely allotted in the happiness they enjoyed on earth alike with their glorious death.

I know it is difficult to find words that will reach the heart because oftentimes you will be reminded in the happiness of others of those joys in which you yourselves did once exult; and your grief is not for blessings you have never experienced but because you have been deprived of those to which you have become accustomed. But those of you who are still of an age to have children ought to take comfort in the hope of others. The children, yet to be born, will be a private benefit to some in causing them to forget those who no longer live and they will be a double boon to their country in preventing desolation and providing for its security; for it is not fair or just that they should give counsel who may not, by having children too at stake, run the same risks as others. But those of you who are advanced in years may consider so much gain that longer past which you have so fortunately enjoyed and that the remainder of your life will be but short and will rest lightly upon you because of the glory these attained. The love of honor alone never grows old and in the useless period of life getting wealth does not please more, as some say, than being honored.

Before you, their sons and brothers, however many of you there are present here, I see a great contest; for everybody is accustomed to praise those who are no longer with us and you would find it difficult to secure a verdict of equality though you surpassed them in valor, but would be thought a little inferior. For the living suffer from the envy that proceeds from competition but the one who is no longer in the way is honored with a good will, far from all feeling of rivalry.

But if I must make any mention of female virtue to you, who will now be reduced to widowhood, I shall express it all in a brief admonition: your great glory is to be found not wanting in the virtue which belongs to your sex, and great will be her reputation of whom the gossip of men says least either in praise or blame.

I have now spoken, in accordance with the law, what I held appropriate, and by our action our dead have already been honored and their children the nation will henceforth nourish and support at the public expense till they become of age—the substantial crown of glory offered to the dead before us and to the survivors of such contests; for where the greatest prizes are offered for

valor, there the citizens are the bravest men. But now let every one indulge his grief in becoming manner and then depart.[4]

Plato, the philosopher, wishing to show by a pattern-speech how the eulogists might, on occasion, express themselves in a more exalted and patriotic manner, makes his old master, Socrates the Wise, repeat, as the mouthpiece of that wonderfully clever woman, Aspasia, the splendid address of which the following is the conclusion:

To the state we would say: Let her take care of our parents and sons, educating the one in principles of order and worthily cherishing the old age of the other. But we know that she will, of her own accord, take care of them and does not need exhortations from us. These, O children and parents of the dead, are the words which they bid us proclaim to you and which I do proclaim to you with the utmost good will.

And on their behalf, I beseech you, the children, to imitate your fathers and you, parents, to be of good cheer about yourselves; for we will nourish your age and take care of you both publicly and privately in any place in which one of us may meet one of you who are the parents of the dead. And the care which the nation shows, you yourselves know; for she has made provision by law concerning the parents and children of those who die in war, and the highest authority is especially entrusted with the duty of watching over them, above all other citizens, in order to see that there is no wrong done to them.

She herself takes part in the nurture of the children, desiring as far as it is possible, that their orphanhood may not be felt by them; she is a parent to them while they are children and when they arrive at the age of manhood she sends them to their several duties, clothing them in complete armor; she displays to them and recalls to their minds the pursuits of their fathers and puts into their hands the instruments of their father's virtues; for the sake of the omen, she would have them begin and go to rule in the houses of their fathers arrayed in their strength and arms.

And she never ceases honoring the dead every year, celebrating in public the rites which are proper to each and all; and, in addition to this, holding gymnastic and equestrian festivals and musical festivals of every sort. She is to the dead in place of a son and heir, and to their sons in place of a father, and to their parents and elder kindred in the place of a protector, ever and always caring for them. Considering this you ought to bear your calamity the more gently; for thus you will be most endeared to the dead and to the living, and your sorrows will heal and be healed. And now do you and all, having lamented the dead together in the usual manner, go your ways.[5]

The closing words of the beautiful oration, delivered by Hypereides over Leosthenes and his comrades who fell in the Lamian War (322 B.C.), pay due tribute to that orator's matchless merit. Far removed from the artificial grief, so common to the panegyric, there is a genuine, dignified sorrow, in the fragment preserved, which bears the mark of sincere though reticent sympathy, and the most expert of modern critics have found a tenderness and trust in this pagan martyr's patriotic exhortation to the kinsfolk of the dead that verges splendidly near the most touching Christian consolation:

[4] Thucydides, Bk. 2, Sec. 43.

[5] Plato, "Menexenus," 249 C., Jowett trans.

It is hard, perhaps, to comfort those who are in such a sorrow; grief is not laid to rest by speech or by observance; rather is it for the nature of the mourner and the nearness of the lost to determine the boundaries of anguish. Still we must take heart and lighten pain as we may and remember not only the death of the departed but the good name also that they have left behind them. We owe not tears to their fate but rather great praises to their deeds. If they came not to old age among men, they have got the glory that never grows old and have been made blessed perfectly. Those among them who died childless shall have as their inheritors the immortal eulogies of Greece and those of them who have left children behind them have bequeathed a trust of which their country's love will assume the guardianship.

More than this, if to die is to be as though we had never been, then these have passed away from sickness and pain and from all the accidents of the earthly life; or if there is consciousness in the next world and if—as we conjecture—the care of the Divine Power is over it, then it may well be that they who rendered aid to the worship of the gods, in the hour of its imminent desolation, are most precious to that Power's Providence.*

Hardly less eloquent were the memorials perpetuated by the sculptor's chisel in handsome marbles and enduring bronze. The matchless, Athenian military relief, raised in the Ceramicus Cemetery to Dexileos, one of the Glorified Five in the dashing cavalry charge in the Corinthian War (394 B.C) still stands, a noble testimonial in marble to the mighty triumph of The Last Battle, with its rearing charger and exultant knight transfixing with his spear the fallen foe. Though this may not be a monument erected by the nation, but the patriotic offering of some friend or admirer, it is valuable for our purpose as one of the few memorials to the individual as distinguished from the triumph of the cause.

But the long and notable list of monuments and trophies to the heroic dead began a century before, soon after Marathon (490 B.C.), with the dedication of the little Doric treasure-house, set up by the Athenians out of the Persian spoils, in the holiest place of Greece, at the oracle of Delphi, "the Center of the Earth," and the point of pilgrimage of thousands, on religious mission bent, from all parts of the ancient world. The remains of this, the noblest memorial of the victory at Marathon, have been found in recent years and the sculptured reliefs of Pentelic marble, safely preserved, with their story of Theseus and Hercules, and the battle of gods and giants—symbolic of the recent contests—reveal a chaste grace that must have given an unique architectural delicacy to the whole structure.

The famous battle-pictures by Micon, in the Portico of Frescoes in the Athenian market-place, painted a quarter of a century later, furnished, however, a livelier idea and glorified most effectively the heroes of this most celebrated battle of history. In one scene, the Athenians charge the trousered Persians; in another, the Persians, in their confusion, rush into the marsh in their flight to their ships; in still

* Hypereides in Jebb's "Attic Orators."

another scene, Miltiades and the Persian admirals appear; Cynegirus, brother of the tragic poet, Æschylus, is there also, seizing the prow of the galley to which he held fast until the axe severed his arm and interfered with his determination to capture a whole ship, single handed. Theseus, hero-god, inspires their valor as he rises from out of the earth and the gods and goddesses, above the battle, on the quiet heights of Olympus, look down on the pictured scene—all of which furnished to the oncoming generations a most potent and patriotic reminder of the services and sacrifices of their citizen-soldiers.

But by far the most artistic and celebrated memorial to the achievements of the Athenian, in arms, was the beautiful little Temple of Victory, on the Acropolis, the Holy Hill of Athens. At the Fore-Gate, near the splendid flight of marble stairs—over seventy feet broad—stood, and stands to-day, the patriotic shrine on a mighty bastion twenty-six feet high. This lofty spot was a most appropriate site for a temple of Victory; for from this height the Athenian saw Salamis and Ægina near by and the distant coast of Argolis, the citadel of Corinth, and the mountains of Megara—memories of the glorious past and rosy hopes of future victories.

Other temples, by allegorical sculptures, represented indirectly the great struggle of the Persian wars, but little "Victory" wrote clear its motive in its marble-band, which portrayed the contest of actual Greeks and Persians in the decisive battle of Platæa (479 B.C.). The little Ionic temple of Pentelic marble is only twenty-seven feet long and eighteen feet wide, but its frieze, running around the whole structure in high relief, is eighty-six feet long, and the four fluted columns, at either end, thirteen feet high, are made from single blocks of marble. Within the temple-room was an ancient, wooden image of the goddess, Athena, wingless, with pomegranate and helment in either hand. The breast-high balustrade, about the three precipitous edges of the bastion, was adorned with marble slabs of winged Victories, erecting trophies and sacrificing to their queen, Athena—all clad in those wonderfully transparent robes of marble gauze, which, clinging to the figure or floating across the marble field, have remained the most renowned example of their kind in the history of sculpture.

One of the most unique soldier's monuments in military annals is the serpent-column of bronze which once supported the golden tripod, dedicated by the Greeks, at Delphi, nearly twenty-four centuries ago, in commemoration of the victory of Platæa. Emperor Constantine removed it to his new capital and it still stands in the Hippodrome at Constantinople with the muster-roll of the loyal peoples inscribed upon its coils.

Among the many memorials erected by the Greeks, surely the most characteristically ancient, in religious motive and martial emphasis,

is the Soros or funeral mound, raised by the Athenians, at Marathon, as a tomb for their fellow countrymen who fell on the spot in battle. The marble lion, which originally stood guard upon its summit, long ago disappeared but the tumulus itself, thirty feet high and two hundred paces in circumference, was excavated by the Greek government in 1890. Nine feet below the present surface of the surrounding plain was found an artificial floor, 85 feet long and 20 feet wide, upon which rested a layer of ashes, charcoal and human bones. A trench was subsequently discovered which contained the remains of the victims sacrificed to the dead heroes. The black figured vases, found with the bones and ashes of the dead, belong to the period of the Persian Wars, and there is no doubt but that the human remains are those of the one hundred and ninety-two Athenians that Herodotus says (Book 6, Sec. 117) fell at Marathon on the glorious day.

And more than this, the Greek showed his devotion to his citizen-soldier not only in the flush of victory but also when defeat turned the splendid anticipations of the patriot into a "Lost Cause," in which the commonwealth went down to its doom in the train of Philip, King of Macedon. The Sacred Band, at Chæronea (338 B.C.), fell fighting to a man, and they made "Chæronea," forever, the symbol of a struggle for liberty. Here, too, the Athenians raised a tomb to their heroes, glorious in their defeat, and the mound and fragments of the Marble Lion of Chæronea are still to be seen on the road to Thebes. The Greek raised his monument to the glorious deeds performed by the volunteer in arms, and in it did not seem to be aware of death or defeat which are apt to characterize the modern testimonial, but looked beyond and above all those inevitable incidents and reared a memorial of incomparable value to the national cause and a miraculous inspiration to brilliant patriotic endeavor—a symbol not of gloom, but of glory, fame and triumph.

Nor did the spirit of democratic Athens content itself with cheers for the dying and offer but a crust for the living; for at a very early period—at least twenty-five centuries ago—a systematic provision for the disabled veteran soldier of the people was entered upon by Solon and continued in apparently unbroken observance down to the day of Chæronea, when the nation lost her sovereignty, soon to be merged in the world-projects of Alexander the Great. In the sixth century before Christ, Solon had a law passed in the case of the wounded soldier, Thersippus—the first name on a pension-roll in history—by which it was decreed that he and all others thereafter "who were maimed in war should be supported at the pubilc expense."[7]

Even Peisistratus, constitutional tyrant at Athens that he was, subsequently endorsed and followed the precedent set by Solon, in this re-

[7] Plutarch, "Lives," Solon, Chap. 31.

spect, either from motives of pure patriotism or as a concession to the popular will and as a profitable asset for use among those who followed and were to follow him. The people were so in sympathy with the old soldier that the mere mention of military service by a veteran of the wars was thought to have a magic influence with the jury in almost any kind of a case, whatever the issue might be, and this can hardly be cited as an instance of looseness of court-practise in old Greek law; for our American juryman has been known to award a verdict in a contract case to the plaintiff "who guarded our liberties," "risked his life," etc., as Wellman, in his recent "Day in Court,"[8] interestingly cites.

The liberal and complete assistance, above bestowed on the disabled warrior by the little Athenian republic, stands out a conspicuous example of popular gratitude and sacrifice, especially when we realize that Rome, mighty mistress of militarism, granted no pension and offered no financial aid to her veteran soldier or to his family till after her republic came to a close and loyalty to the public weal had yielded to allegiance to an emperor.

The help, originally given in the case of wounded soldiers, was extended to all those infirm in body who were rendered less able to make a living because of their disabilities and were, at the same time, rated on the census-rolls at less than three minæ—fifty-four dollars, but with great purchasing power:[9] If the modes of appointment to both the civic and military pensions were similar—as is now commonly implied and quite generally admitted—we possess interesting data of the way in which the people at Athens kept a patriotic yet prudent hand on the situation at all stages of the administration of state-aid, including the grant to the veteran citizen-soldier. The people themselves might examine every case both on the original allowance and at its renewal each year, so that there was but slight danger of abuse from imposition on the part of the unworthy.

Action could be brought by any citizen before the Boulé or unicameral Senate of the Five Hundred, against any suspect who was liable to an annual examination by the body or the public. Lysias, the celebrated Athenian speech-writer, wrote his famous defense of "The Cripple" (oration 24) for a poor but unabashed pensioner, the slinging and stinging nature of which fits so well the subject on trial that the speech is probably the best example of keen character-study ever produced by an expert, and has, despite its oftentimes ludicrous utterances, a bathos—and a pathos too—that justifies its being adjudged the most typical and may be the best of Lysian achievements. The virtually direct award and renewal of the grant by the people—possible in a limited community, if not practical in a larger nation—with one's

[8] Page 197, edition 1909.

[9] Aristotle, "Resp. Ath.," 49, 4.

neighbors, friends or, may be, rivals, helping the worthy or hindering the worthless, has a democratic flavor that smacks of fair play as well as political thrift and popular control. So far as the ancient authorities at present reveal, the pension to the old Athenian volunteer himself was awarded solely on the basis of disability and financial need—a simple yet satisfactory rule for a small nation where gratitude to the patriot came to mean sacrifice on the part of the people.

The law of the land reflected the humanity and patriotism of the loyal Athenian still further by offering complete support and protection to the fathers and mothers and elder kindred of the dead soldier, as noted in the above quotations from the funeral speeches. This pension, which furnished a substantial consolation to the dying warrior and an incentive and exhortation to those left behind, was put under the immediate supervision of the Archons—the highest authority in the land—who were especially entrusted with the duty of watching over the parents and children of those who died in war that they, above all other citizens, might be free from harm and wrong.

The nation also assumed the guardianship of the sons of veterans together with the daughters of the dead soldiers of the republic of Athens. These orphans were cared for during their minority and were trained and educated at the public expense, and with a completeness of compliance with the best standards of the day that the most progressive military powers of our twentieth century can hardly claim to have surpassed in their patriotic treatment of the survivors of the defenders of their lands and laws.

Although we can not prove the date of this Athenian regulation, Aristotle's censure in his "Politics," of the scheme for support of veterans' children, proposed by the engineer and reformer, Hippodamos, shows that a law like this was already in force at Athens before Pericles's day, the fifth century before Christ. In the same passage[10] the philosopher also claims the existence of similar legislation in other cities (city-states) of Greece. It is now thought quite possible that Hippodamos—who originated the rectangular system of streets in Europe; occupied himself minutely with the improvement of the judicial system at Athens; and possessed a legal mind of such originality as to present the pioneer idea in history of a supreme court of appeals—was not a dilatory mover of a law already in force, Aristotle to the contrary notwithstanding, but suggested new and improved proposals in pension legislation, which, in its old form, had already proved of great civic and patriotic value. The subject most certainly received widespread and intelligent consideration.

Though the offspring of citizens, who fell in the wars of freedom at

[10] Aristotle's "Politics," Bk. II., 8, V., 4, and notes, p. 272, of Susemihl and Hicks's edition.

Athens, was exceedingly numerous and their care no light task in a small nation, she took part in their nurture with a striking delicacy of treatment, "desiring, as far as it was possible," as Plato has said in the Menexenus, "that their orphanhood might not be felt by them," and, in addition to support and education during her youth, the laws bestowed on the veteran's daughter, on her marriage day, a marriage portion or dower which was not only a substantial symbol of parental love and protection, but the very badge of legitimacy in the ancient society.

The sons of veterans were not treated as mere dependent charges of the government but, besides receiving their support from the nation, were taught a trade or trained in business to equip them for the battle of life, and were honored with signal marks of public favor in the gymnasia and especially in the sacred choruses of the great national festivals, in which the proud sons of the most prominent families of the Athenian republic felt it a distinction to appear and participate. And finally, when the veterans' sons, who had been wards of the nation, reached manhood, they were released from state control to take their places as ordinary citizens among their fellow countrymen, but amid scenes and ceremonies which were the most dramatic and inspiring on the religious and patriotic calendar.

No more conspicuous place and surely no more auspicious time could have been selected for this glorification day of the soldier's boy; for he was emancipated from his happy tutelage at the March season of the presentations in the great stone theater of Dionysus, which seated thirty thousand people, when filled, as it was sure to be at this time, when, in addition to the large attendance from the Athenian city and nation, many thousands were drawn from all parts of the Greek-speaking world. Here, at this time, the great tragedies of Æschylus, Sophocles and Euripides, the epoch-making comedies of Aristophanes, and the plays of the other noted dramatists were brought out, just across the way from the temple of the wine-god, with whom the ceremonies always began, and in whose honor and worship drama originated and developed.

Amid such surroundings and in the midst of such a multitude, on the gala day of the year, these orphans were presented, clad in full armor, as a symbol and memento of their fathers' valor and as an exhortation to follow their fathers' example. Just before the tragedy proper began, and after the sacrifice, the bestowing of civic and military crowns on the nation's greatest and bravest, and the sacred deposit of the tribute from the "Athenian Empire"—the safety-fund from the protective league against the Persian King—these youths were introduced to the assembled audience by the herald, who proclaimed with loud voice, what the orator Æschines—Demosthenes's great rival—

regarded as a most glorious and valor-inspiring proclamation, recounting that "the fathers of these youths, like brave and good men, had fallen in their country's battles, wherefore the nation had taken charge of their bringing-up, and now on the verge of manhood, having adorned them with an entire suit of armor, dismissed them under happy auspices to watch over their own affairs, granting them likewise most honorable seats in the theatre."

Though the services rendered by the old Greek volunteer were not only national, but even continental in their influence, their recognition by the most celebrated and artistic memorials of the day, and by pension legislation—which, even in the fragmentary laws and references preserved, suffers little, if at all, by comparison with the finished product of the twentieth century—shows a devotion and sacrifice on the part of the people, unique in their loyalty to the constitution of that first republic in the world, political prototype of the great American republic in nearly everything but size. The people of Athens knew no king but law, and early learned that the stability and very existence of a republic, more than any other form of government, depend on gratitude to the citizen-soldier who defends the constitution, and on the creation and cultivation of a spirit of loving allegiance to and loyal observance of the supremacy and sanctity of the law of the land; and the little republic insisted on that truth and taught her citizens that lesson—which all republics must learn sooner or later—but probably never with more striking or exemplary emphasis than in the oath the youth was required to take at the Temple of Aglauros, when, as citizen and soldier, he swore

> That he would not disgrace his arms nor desert his comrade in battle but would fight for his country's shrines; and leave his fatherland not feebler than he found it but greater and mightier; that he would obey the orders of his commanders; that he would keep the laws, not stand idly by if any one violated or disregarded them, but do his best to maintain them; and that he would honor the shrines of his native land.[11]

[11] Lycurgus, "Leocrates," § 76.

LANGUAGE AND LOGIC

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WHETHER language is coordinate with thought and merely a phase of it; whether it may be used with a very slight admixture of thought; or whether thought is possible without language, are problems that have engaged the attention of thinkers from the dawn of philosophy. That articulate speech is possible without thought, at least to a limited extent, is evident from the lingual activities of children. They talk almost incessantly during their waking hours either to themselves or to others. That thought precedes speech seems to have been the general belief until comparatively recent times. That this was the view of the writer of Genesis, who probably followed an older, perhaps a much older tradition, is evident from the words "and whatever the man (or Adam) called every living thing, that was the name thereof." The author of this statement clearly believed that the first man was fully endowed with the rational faculty and that speech was merely the utterance of a regulated mental activity. The close connection that was supposed to exist between words and thoughts and their potency in the realm of matter is also shown in the account of creation when the different objects were called into existence by the words of the Lord. Probably few persons of the many millions who have read the first chapter of Genesis have taken note of the naïveté of the record. No living being existed except God; yet he is conceived as uttering his purpose every time he performs a new act of creation. He can therefore have talked only to himself. So we have the oft repeated, "And God said." To what extent our common modes of speech are dominated by the spoken word is evident from such expressions as: "What does the book say?" "What does the law say?" "The newspaper says nothing about it." "He can't tell the difference between black and white." "The heavens are telling." "My conscience tells me." "Money talks" and many more. In one of the South African languages "to think" is expressed by "to talk in one's belly." In this primitive way of looking at the problem the utterance of a thought is taken to be of more importance than its genesis. The Logos doctrine that was so fully elaborated by the later Greek and the earlier Christian philosophers is clearly related to the same underlying conception. "In the beginning was the Logos" are the first words of John's Gospel, by which he means the divine reason. This idea is dwelt upon by Goethe in his Faust. When the hero begins to read he says: "In the beginning was the *Word,*

Here I am balked: who now can help afford?
The Word?—impossible so high to rate it;
And otherwise I must translate it
If by the spirit I am truly taught.

So he tries again.

In the beginning was the *Thought.*
Is it the Thought which works, creates, indeed?

Another attempt leads him to translate:

In the beginning was the *Power.*

Finally he declares:

The spirit aids me: now I see the light!
In the beginning was the *Act,* I write.

Many volumes have been written to explain the meaning of the mysterious word Logos, yet the underlying idea does not seem particularly difficult of comprehension. The abstruse doctrines that have been built upon it are another matter. The writer of the fourth gospel understood it to mean the divine reason that existed before anything visible or tangible was created, and through which "everything was made that was made." It was an effort on the part of the dualistic philosophy to account for the creation, or at least for the orderly arrangement of matter, by a power that dwelt outside of it. As matter could not have produced God, God must have produced matter. In the older Jewish philosophy, so far as their thorough-going belief in the constant interference of the Deity in everything can be called a philosophy, the problem never found a place. It also engaged the attention of the early Greek philosophers. We find the same notion underlying Plato's doctrine of ideas, which is not difficult to comprehend in its main outlines. He evidently means that the concept of things exists in the mind of the self-existent designer before the objects themselves are called into being, just as a man who undertakes to make any *thing* has a plan in mind before he enters upon his work; when it is completed the abstract idea is concretely realized. In like manner, a quality may be conceived abstractly before it is embodied in concrete form. In the Cratylus, Socrates asks whether "our legislator ought not also to know how to put the true natural name of everything into sounds and syllables, and to make and give all names with a view to the ideal name, if he is to be a namer in any true sense." The thought was anterior to the word which expressed it. The mind exists independent of the body; it therefore possesses innate ideas, ideas that had a previous and incorporeal being. The idea of justice, for example, existed before it was embodied or externalized in just acts. The maker of a statue, or of a table, or of a house, had in mind its idea or mental image before he could give it a visible form. The visible is fleeting, the conceptual is abiding. This doctrine was developed in contradistinction to that of

Heraclitus, who taught that all things are in a state of flux, and to that of Protagoras in ethics who maintained that man is the measure of all things. Plato doubtless carried his doctrine to an unwarranted extreme, but that there is much truth in it will hardly be doubted. Neither the mute man nor even the mute child is without ideas. The ability to mould language so that it will fit thought closely is the highest human achievement, but it is not essential to thought. The thought-processes of deaf-mutes are to some extent beyond our grasp, but not wholly out of the range of the constructive imagination. It is well to note, furthermore, that our word *logic* is the direct descendant of Logos. Whatever technical or philosophical definition we may give to logic, there is no doubt that speech and rational thought were closely associated in the minds of the Greeks as the history of the term proves. In their philosophical systems dialectic, discussion, question and answer were so intimately connected and interwoven that they were unable to think of them as separated. People who live in an age of books can only realize with a mental effort conditions when they were non-existent or rare. The poet-philosopher Euripides, who flourished about the middle of the fifth century B.C., is said to have been the first man to collect a library. In the nature of the case it must have consisted at most of only a score or two of manuscripts. Besides, he lived in Athens, the center of culture in the ancient world; elsewhere there were strictly speaking no books at all. Our dictionaries designate what they believe to be correct usage. At any rate, they do much to establish it by setting up a standard to which all educated persons endeavor to conform. In this way a language becomes stereotyped to such an extent that it changes very slowly. But dictionaries in the popular sense are of comparatively recent date. The Greeks always felt justified in using any word or phrase they found in Homer, just as we do with respect to biblical or Shakesperean phraseology. But these authors did not get their vocabulary from books. Later writers, notably Plato among the Greeks and Cicero among the Romans, endowed with the power of genius, may be said to have created a language; it was subsequently imitated with more or less success by all who strove after elegance of diction. But it is doubtful whether they formed a single word in the sense in which a modern scientist may be said to do so. Neither does a man who makes a machine make the materials that enter into it. The influence of these two writers is still vibrant in all philosophical and ethical discussion. The same may be said of Kant, another of the world's great thinkers and one of its original geniuses, since he was not much interested in ancient philosophy and preferred to grapple with the problems he set out to solve without the intervention of predecessors. While we can not tell how thought-processes are carried on without words, that they are so carried on does not admit of doubt.

Facts of a strictly scientific character are furnished by the study of deaf-mutes. In my boyhood I was well acquainted with one of these so-called unfortunates. He was a blacksmith, having learned the trade from his father, and was associated with him in the business. When the father desired him to do anything he addressed him in his natural voice: "Dan, I want you to make a lot of horse-shoe nails"; or he might speak of something that had no connection with the shop as: "To-morrow we will plant corn." This young man had never had any systematic instruction and simply "picked up" his knowledge of English. In order to get some further light on the connexus of speech with thought I addressed a letter of inquiry to superintendent Jones of the Ohio Asylum for the Deaf. I quote from his reply.

I take it your questions refer to the congenitally and totally deaf children. Uneducated deaf-mutes would likely have an inarticulate noise to designate a horse or a cow. Many such children have no such noise at all, but designate them by marks or signs. Educated deaf children under the latest system of teaching speech would have a distinct articulate name for "horse" or "cow," and in fact for all objects, actions, etc.; not so clear however as the hearing person but yet clear enough to be understood. The deaf-mute carries on processes of reasoning just like the hearing person. Speech is not necessary to reasoning, neither is language. To those who are familiar with the uneducated deaf child, it is well known that he is in no wise apparently different from his hearing brother. If nature's touch has not dwarfed or deformed his mental powers, he is alert, active, quick to comprehend, quick to act and responsive to calls upon his attention. His body is vibrant with energy and yields readily to the activities of play and games. He answers the call of his parents to do chores about the house with the same interest and enthusiasm as the other children. He is familiar with the fields, orchards, trees which are near and around his home. He is acquainted with the call of the physician and the visit to the dentist and oculist, and knows the official function of one from the other. Every piece of household furniture he knows and its use. He knows the domestic from the wild animal; the one to pet and the other to flee from. In fact as far as ideas are concerned he has perhaps as clear a conception of the uses of everything around him as the other members of the household. Yet he knows not a name of one. The accepted philosophy up to the close of the sixteenth century and the beginning of the seventeenth declared that the deaf child could not be instructed because he lacked language. This doctrine was upheld by some of the brightest minds that our most enlightened countries of the middle ages and thereafter furnished. It was however discovered that a great many bright deaf people had learned to express themselves in various ways, showing their minds as abounding in good ideas with an understanding of the nature and work of almost every thing with which they came in contact, although they were unable to speak, read or write a single word.

The facts above reported, as well as those that have come under my own observation, partake largely of the mysterious. Speaking for myself, I can not comprehend how it is possible to carry on a process of reasoning wholly without the use of words. Such vagaries as we find in "Alice in Wonderland" are not the product of reason, but rather of the constructive imagination as distinguished from the creative. They are

much like the products of the mind in dreaming where it is not under the control of the intellect and the will. I find no difficulty in the comprehension of mathematical formulæ, or in grasping the idea of time and space, or of the persistence of force, or of the indestructibility of matter, apart from the terms in which they are stated; but these are propositions quite beyond the mental reach of the child. The theory that we use words as supports just as a lame man uses crutches until he is healed, breaks down before the fact that children do not need verbal crutches and are able to walk, figuratively speaking, without them. It is probable that every normal child born in a civilized community is endowed by nature with certain hereditary capacities which are then spontaneously developed up to a certain point under the influence of its environment. If the development is to be carried farther, the child's environment must become aggressive and begin a course of training. In fact, what we call culture or civilization is the result of an effort exerted continuously by a small part of the community under pressure of the state upon the whole. There is no doubt that men existed in South Africa as early as in northeast Africa; yet in the former region they never got far enough from the primitive stage to construct a government in the modern sense of the term. When in the course of time this small minority loses its efficiency, the disintegrating forces gain the upper hand and the state falls to pieces. This was the fate of all the pre-christian commonwealths and may be the ultimate fate of all that exists at the present time. The educational agencies of a culture-state are engaged in the endless task of rolling a stone up the hill of progress with more or less success. But as soon as the propelling force is relaxed it will probably begin to roll down. With each generation the work has to be done over again almost from the foundation; in other words, there is a constantly oncoming crop of young savages to be tamed and trained. The reason why the Mesopotamian and the Egyptian kingdoms, the Greek and Roman governments, decayed was that the intelligent minority was overslaughed and eventually destroyed by the atavistic agencies that had at no time ceased their activities. The state had foes within and foes without. It was able to withstand both for centuries, but not for ages. They had simply been kept in check. Heroes, as Carlyle would call them, endowed with varying degrees of efficiency built up states and their successors maintained them. The process was partly spontaneous, partly purposive. In like manner language is a spontaneous growth up to a certain point. It never passes beyond this point unless it becomes the object of mental effort. But even effort is powerless beyond a certain stage. No amount of education can make a great writer, or a great poet, or a great orator, notwithstanding Quintillian's dictum that the orator is made. Neither is any government sufficiently powerful to force a language upon a re-

fractory people, as may be seen in the case of Prussian Poland. I quote further from Superintendent Jones:

> The best way of describing the language of the partially educated deaf child is to say that it is mixed. The order of words has always been a bugbear to them. The various verb-forms have given them much labor and worry. They are liable to use one part of speech for another, using nouns, adjectives, adverbs, etc., as verbs. A most striking illustration of that came to my notice a short time ago. One little boy was seen to strike another in the class. His teacher reproved him. His defense was "I whyed him and he wouldn't because me." A teacher had taken her class to see the seventeenth regiment leave for the Philippine Islands. She desired to use the occasion for journal writing and as a language drill. On their return the pupils were to write what they had seen. One boy wrote: "Many men were banding, but I did not see them horn." Evidently he was impressed with the great number of men in the band, but noticed that they were not playing when they passed him. A girl in describing sheep-shearing said: "The farmer washed and nicely the sheep."

The last quotation throws considerable light on one aspect of our vocabulary. It is generally held by philologists that the ultimate elements into which all languages can be resolved consist of two sets of radicles, verbs and nouns, all other parts of speech being derived from these. That our grammatical nomenclature is mainly artificial is not to be doubted. Persons without education are unable to see any difference in the functions of words; often, in fact, these are very indistinct. It is a dictum of Homeric Grammar that all propositions were originally adverbs. In English, as in most other languages, almost any part of speech can be used as a verb. I have heard such expressions as: "I don't want anybody to thee-and-thou me." "No if-ing, if you please." The French have a verb *tutoyer,* meaning, "to address another with thee and thou." "If" is probably the instrumental case of a word expressing doubt. Whether, neither and either are plainly comparatives. It is an utter waste of time to discuss the grammatical classification of words. In Greek and Latin the infinitive of the verb and the dative case of the noun have the same sign. The same statement is true in a modified form of the English, as we may see in such phrases as to me, to town, to go, to walk. "To walk makes me tired," hardly differs from "Walking makes me tired." In German any infinitive can be used as a noun, as also in Greek.

The imperfection of language allows the writer to reveal himself. It is because language displays but a part of this subjective world that there exists an art of writing. James Darmesteter in his "Life of Words" says:

> If language were the expression of thought and not a more or less happy attempt at such expression, there would be no art in good phraseology; language would be a natural fact like breathing and the circulation of the blood, or like the association of ideas. But owing to that imperfection, we make an effort to get a grip of our thought in all its turnings, in its inmost folds, and to render it better, and hence arises the work of the writer.

This statement, although true to a limited extent, is applicable only to a small minority of mankind. The overwhelming majority is so much under the sway of tradition and possessed of so few new ideas that their vocabulary is entirely sufficient to afford them utterance. Much more to the point is the following:

> Everywhere as the ultimate end of change we find two intellectual co-existing elements, the one principal, the other accessory. After a long while and by an unconscious path, the mind loses sight of the first, and only considers the second, which either drives out the first or restricts its value. Under cover of the same physiological fact—the word—the mind passes from one idea to another. Now this unconscious process carrying the dominant fact from the principal to the accessory detail is the very law of transformation which obtains in the moral world. The history of religions, of social institutions, of politics, jurisprudence and moral ideas, may be reduced to that slow process which causes the unconscious habits of mind to forget the primary fact, to see the secondary fact alone which is derived from it, and to make of it a primary fact which in its turn will disappear before its insensibly increasing successor.

While the origin of the ultimate constituents of words is rarely discoverable, we can often trace their descendants up to our own time. Typical terms are "derive," "rival," "derivation," "rivulet," and many more that on the surface do not appear to have the most remote connection with one another. The ancient Romans called a stream *rivus*. To draw water from a stream was called *derivare*, the act *derivatio*. *Rivalis* was one who lived on the banks of the same stream. The idea of competition or rivalry is probably latent in the term. The insight we get from other sources into primitive conditions makes it plain that every man's hand was against every other man's. We have by no means outgrown this stage. Thucydides testifies that in his time in some parts of Greece the peasants went to work in their fields with arms in their hands in order to be prepared to fight for what they considered their rights at all times.

The Roman soldiers received no pay for their services while in the field, but the state gave them a small allowance for the purchase of salt, an indispensable but costly article of diet, in many places hard to get. This allowance was called *salarium*, whence our familiar word salary. So likewise *emolumentum* was the money paid for grinding the grain. *Lira* means a "furrow," *lirare* to make a furrow, *deliro* to get out of the furrow, *deliratio* a getting out of the furrow; hence, folly, madness. The connection of these words with *delirium* and *deliramentum* is plain. They were evidently formed when the ancient Romans were an agricultural people. That the conclusion follows from the facts is as clear as the law of deduction can make it. A current German phrase to designate mental aberration is "to be out of one's hut." A word that exhibits this gradual change, or rather, extension of meaning almost under our eyes, as it were, is our familiar

term "to ship." The verb came into use at a time when goods were generally transported by water; then it was extended to include conveyance by land likewise. Now it is employed to designate the activities of any common carrier whether by land or water. The original signification has been so completely lost that very few persons who use the word think of it, or notice the incongruity between the term and its primitive meaning.

It is almost certain that a good many words—and there is no way of discovering how large the number—are the spontaneous utterances of persons who can give no reason why one form was chosen rather than some other. To this class belong boom, skedaddle, hoodlum, hooligan, spondulicks and a host more. I recall that several words were current in our neighborhood in Pennsylvania to designate certain persons and acts and were usually referred to their authors. As they never got into print they may have since died out. It is easy to see how, in a primitive state of society, a word uttered by some chief would be taken up by his entourage and eventually become a part of the language of the clan; for although language is developed by society, it does not owe its origin to man's gregarious instinct. Every one knows that children often invent names for things that have no relation to or connection with words used by older persons. The theory that the hypothetical *pithecanthropus* was the progenitor of man is no longer held by any competent anthropologist. If we place the fossil remains discovered by Dubois in the island of Java in this class the argument is not strengthened, the chief objection being its comparatively late date. According to the recent and very careful examinations of Klaatsch and Hauser of all known fossil remains of man there were two primitive types which they designate as the Aurignac and the Neanderthal races. Of these the former stood considerably higher than the latter and unquestionably possessed the faculty of speech. With regard to the latter the evidence is not quite so convincing, but is sufficient to produce a high degree of probability, especially in view of the fact that this race, anatomically considered, bore a striking resemblance to the Australian aborigines; and these display a large measure of linguistic capacity.

Although words are often used eventually in a widely different sense from that which they originally bore, the progress from one meaning to another is not always gradual. The first man who used *ship* to designate transportation by land doubtless did so with a clear knowledge of its original signification; this was only forgotten in the course of time. The man, probably a sailor, who invented the article now considered indispensable by seamstresses named it a "thumb-bell" for evident reasons. The Germans call it a *Fingerhood*. Yet it is safe to say that very few English or Germans now think of the original meaning of the word, though it was clearly evident when it first came

into vogue. Shortly after Chinese trade was thrown open to American shipping a vessel was lying in one of the treaty ports. A Yankee sailor who happened to be on shore noticed some natives digging a ditch and carrying away the earth in their blouses. Thinking to teach them a valuable lesson, he provided them with a wheelbarrow and showed them how to use it. Coming to the same workmen some time afterward he saw them carrying the wheelbarrow. They found it less trouble to do so than to learn to use it in the proper manner. We have here a practical illustration of what Lord Bacon had in mind when he said that new ideas are conceived in the old way. Many words experience the same fate. They are used for purposes for which they were not intended originally. The mind expands faster than the vocabulary increases, and it is easier to use the old word with a new meaning than to invent a new one. In this way a great number of new significations are sometimes grafted on a stem that may be called hoary with age. According to de Mortillet who has probably devoted more time to the study of the problem than any one else, man has existed upon the earth not far from 240,000 years. Of these about ten thousand belong to the culture period, and six to the historical. We may greatly reduce the first period and it still remains very long. Primitive man had need of but few words. In the nature of the case his vocabulary would increase very slowly. If not more than one or two words a year were added to it he would enter the historic stage with a relatively large stock. The Hebrew Bible contains less than nine thousand words. A writer says, in the introduction to Worcester's dictionary, that the English language embraces about thirty-eight thousand words. "This includes not only radical words, but all derivatives, except preterites and participles of verbs." The Anglo-Saxon vocabulary is about one third smaller. The Greek language up to the time of Aristotle includes about forty thousand words. Why our modern lexicons are so much more comprehensive is easily explained. The fundamental problem, as it looks to us, that primitive man had to solve was how to designate by the sound of his voice objects that were hushed in perpetual silence. He might imitate, however imperfectly the roar of the tempest, the thunder-clap, the noises made by birds and beasts; but how should he designate the sun, the moon, the stars, the flowers of the field? Did his fancy come to his aid so that he felt like the Psalmist when he speaks of the time when the morning stars sang together and all the sons of God shouted for joy? To this question science has no answer and the answer furnished by the imagination is worthless except as a curiosity. Hence the problem of the origin of language has almost ceased to engage the attention of investigators. Every possible theory has been advanced, but none has gained general assent. It may aptly be said to have been consigned to the limbo of unrealizable possibilities.

THE LANGUAGES OF THE AMERICAN INDIANS

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THE day is past when educated people believed that the Indian languages were only random jargons of a few inarticulate sounds, without grammar or order, and so badly in need of supplementary gestures to make them intelligible that the Indians could not converse in the dark. Still farther have we got beyond the point of speaking of *the* Indian language, as if all tribes used essentially one and the same idiom. Such notions may yet linger among the uncultured, and now and then reflections of them still crop up in books written by authors whose knowledge is not first hand. But the progress of science has been so great in the last half century that the world now looks upon the tongues of the native Americans with newer and sounder ideas.

Probably the most important and most surprising fact about American Indian languages is their enormous number. On the North American continent there were spoken probably 1,000, and possibly even more different languages and dialects. Of South America we know less, but everything points to an equal linguistic variety on that continent. The tremendous total is astounding because the aboriginal population in both continents certainly numbered fewer millions than are to-day found in many single European countries in which only one language prevails. The twenty-five or fifty millions of American Indians possessed as many different languages as the billion or more inhabitants of the old world.

Language and History

To the historian and the ethnologist this linguistic diversity is of the utmost consequence, because it affords him his most important means of classifying the native peoples of America, and ascertaining their connections, their migrations and in part even their origins.

To the student of old-world history and ethnology, philology is also a serviceable handmaid, though to a less degree than in America. This happens, in the first place, because the languages of the eastern hemisphere are, on the whole, each more widely spread; and secondly, because history and archeology carry our knowledge of many peoples of Europe, Asia and Africa back for thousands of years—as compared with the bare four centuries since the discovery of America. History is, therefore, much more able to stand on its own feet in the old world than in the new. Nevertheless, when the historian goes back to origins,

he has always been compelled, even in Europe and Asia, to call in the aid of language, and sometimes with the most fruitful results.

Starting, for instance, with our own language, English, the tongues nearest of kin to it are Dutch, German and Scandinavian. Next in closeness of relationship are the various Romance languages, evolved from the decay of ancient Latin—such as French, Italian and Spanish. Still more different, but yet with sufficient similarities to make relationship and ultimate common origin absolutely certain, are Russian and the other Slavic languages, Greek, Armenian, Persian and the various Hindu dialects. The Englishmen who first heard Hindu speech certainly did not suspect that the languages of these dusky people were similar to their own, and that a direct connection or community of origin must at one time have existed between the Englishman and the Hindu. Yet philology has shown such to be a fact, which is now a matter of common knowledge, the entire group of languages spoken from England to India being known as the Indo-European family or Aryan stock.

When a student of Hebrew examines Arabic, it is very quickly evident that the languages have much in common. The speech of the ancient Phœnicians, Syrians and Babylonians, and of the modern Abyssinians, is also similar. This group of languages constitutes what is called the Semitic family. Every dialect within the family possesses obvious similarities to every other Semitic dialect, just as all Aryan languages possess certain words and features among themselves. But no Aryan language has any resemblance to or connection with any Semitic language. It is therefore clear that the ancestors of all the Semitic-speaking nations must have had, at some far distant time, a single common origin, and that at this period they were entirely separate and distinct from the progenitors of the peoples that belong to the Aryan family.

The Turkish language is entirely unconnected with either Aryan or Semitic and belongs to a stock of its own. We know from history that the Turks are recent immigrants in Europe and that they came not very long ago, as the historian reckons, from central Asia. But if the Turkish migrations and invasions had taken place 2,000 years earlier than was the case, we should in all likelihood have had no historical record of the fact, and the historian would erroneously classify the Turks as related to the neighboring Aryan nations—unless he called upon philology to aid him.

It has often been asserted that languages are readily learned and unlearned, and that races put them on and off as a man dons or doffs a garment. But in reality there is probably nothing, not even physical type, that is as permanent as a people's speech.

Thus, even to-day Breton, a pure Celtic speech, maintains itself in

France as the every-day language of the people in the isolated province of Brittany—a sort of philological fossil. It has withstood the influence of 2,000 years of contact, first with Latin, then with Frankish German, at last with French. In the same way, its Welsh sister tongue flourishes in spite of the Anglo-Saxon speech of the remainder of Great Britain. The original inhabitants of Spain were mostly of non-Aryan stock. Celtic, Roman and Gothic invasions have successively swept over them and finally left the language of the country Romance; but the original speech also survives the vicissitudes of thousands of years and is still spoken in the western Pyrenees as Basque. Ancient Egypt was conquered by the Shepherd, the Assyrian, the Persian, the Macedonian and the Roman, but whatever the official speech of the ruling class, the people continued to speak Egyptian. Finally, the Arab came and brought with him a new religion, which entailed the use of the Arabic language. Egypt has finally become Arabic-speaking, but until barely a century ago the Coptic language, the daughter of the ancient Egyptian tongue of 5,000 years ago, was kept alive by the native Christians along the Nile; and even to-day it survives in literature.

While nations, like individuals, can learn and unlearn languages, as a rule they do so only with the utmost reluctance and with infinite slowness. Speech tends to be one of the most persistent and permanent ethnic characters.

Indian Linguistic Families

The seemingly endless Indian idioms are by classification reducible to about 150 groups or families, almost equally divided between North and South America. The first problem of American ethnology, after determining and mapping these families, is to deduce the probable migrations of peoples that can be inferred and the connection which existed between different tribes. The second task is to carry out similar inquiries *within* the bounds of each group or family, and in this way to ascertain the minor or more recent affiliations and movements.

The number of languages is large; the aboriginal population was relatively sparse; the necessary consequence is an unusually small number of people per distinct language. In California, where the linguistic diversity reached its height, there were spoken about 135 idioms belonging to 21 families. The total Indian population was 150,000 or a little less—an average for each dialect of almost exactly 1,000 souls, and only 7,000 for each linguistic family. There is something incongruous in comparing the tongue of a paltry 7,000 uncivilized people with, for instance, the whole group of Aryan languages that are the birthright of hundreds of millions of people of the most important nations. Yet to the ethnologist such comparisons are a necessity, for each group of related languages, whether extending only over a little valley, or spreading from continent to continent, is an ultimate unit in itself, which

can not be brought into connection with the other or with any other group. Historically the small family may be as significant as the large, for it represents just as separate an origin.

The Great Uto-Aztekan Stock

Perhaps the best known and most important single tribe in America were the Aztecs, who founded and held the city of Mexico and ruled from there over a large part of the modern republic of that name. Excepting perhaps the Incas of Peru, they were the most powerful nation in the new world at the time of its discovery and conquest. Their

civilization, though for the most part borrowed from other tribes rather than invented, was also of the highest. As to their own origin the Aztecs had certain traditions, according to whose testimony they came

from a point in the north, called Aztlan, less than a thousand years ago; in other words, some four or five centuries before the overthrow of their empire by Cortez.

While historians have usually accepted this native tradition, philological evidence renders it very improbable. The Aztec language, more properly called Nahuatl, is the southernmost of a trailing chain of related dialects extending through the length of Mexico and the Great Basin region of the United States. Being at the southernmost extremity of this chain, we have every reason to believe that the Aztecs have moved southward—just as it is natural that the Hindus, who are the easternmost of the Aryans, entered India from the west, and the Celts, who are the westernmost, came into their territories from the east. But if the Aztecs had come from Sonora or adjacent parts of northern Mexico as late as four or five centuries before the discovery, their language should still be very similar to the dialects of those districts. This is not the case. Aztec and the languages of northern Mexico are related, but the relationship is undoubtedly distant. In other words, the Aztecs separated from the Indians of northern Mexico so long ago that their language became considerably changed, and there is every reason for believing that they have maintained a separate existence for very much more than 500 years, just as it is a moral certainty that the ancient people speaking Sanskrit, Greek, Latin and Gothic broke loose from one another more than five centuries before we first hear of any of them. Languages do not change over night. In other words, because Aztec is a member, but a *detached and divergent* member, of the great Uto-Aztekan family, it is necessary to conclude that the Aztecs came from the north indeed, but came at a very ancient period.

Cliff Dwellers and Pueblos

In New Mexico and Arizona there formerly lived the Cliff Dwellers, and have lived in historical times the Pueblo Indians, builders of large villages of stone, and constructors of irrigation ditches and other remains of a monumental character. These relics so far surpass anything else found in the United States that the superiority of the Pueblos over all their neighbors is unquestioned. This superiority has led to their being brought into connection with the Aztecs, as the nearest nation that had risen to a similar proficiency in arts and industries.

The Cliff Dwellers and the Pueblos are, however, known to be practically identical in their arts, implements, architecture and even religion—so far as idols and symbols and other visible remains can make the nature of an ancient religion evident. The two peoples are clearly only ancient and modern strata of one race. If, therefore, the ancient Cliff Dwellers were Aztecs, the Pueblos should still show in their language close kinship with the Aztecs. This is not the case, the Pueblo

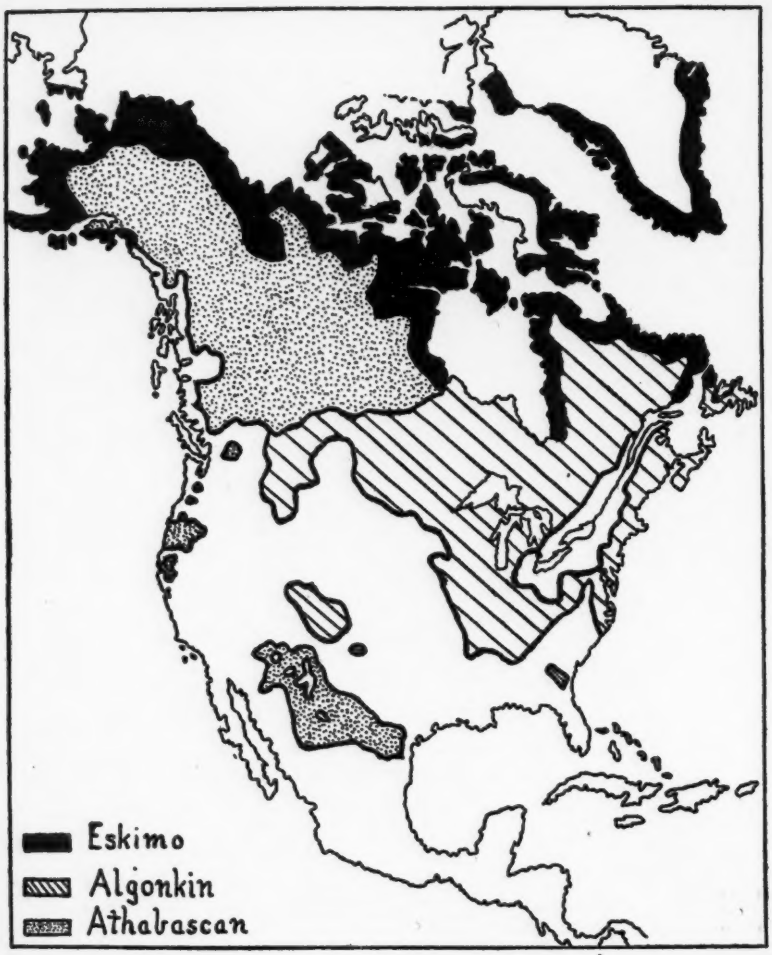
Indians, as a class, not being in any way related in speech to the Uto-Aztekan family. It accordingly follows that the popular identification of Cliff Dwellers and Aztecs is based only on ignorance or imagination, and that the weight of historical evidence is adverse to this view.

The historic development of the great Uto-Aztekan family has been determined still farther. One branch comprises a number of tribes in California. Until recently all these tribes were believed to have been the result of a single immigration into the state. It is now clear that they represent three distinct strata. One mass of them has been resident in southern California for a very long time, long enough for the originally uniform language to divide into several dialects. Another body came at a different time, or by a different route, into the Sierra Nevada Mountains of central California. Whether this movement was earlier or later than the first mentioned we can not yet tell, but it is certain that it was distinct. The third stratum is represented by a recent movement from Nevada westward into the eastern parts of California; but even this was entirely prehistoric.

The Algonkin Family on the Atlantic

Another of the great linguistic families of North America is the Algonkin, one of the first to be known. To this large stock belonged Powhatan, Pocahontas and the other Indians among whom the English settlers of Virginia formed their colonies. Other Indians of the same family formed their treaty with William Penn, sold Manhattan Island to the Dutch, met the Pilgrims from the Mayflower, and learned to read Eliot's bible. Most of eastern Canada, the Ohio Valley, the Great Lake region and the country north to Hudson Bay, were also occupied by Algonkin tribes. Separated from all these, and far to the west of the Mississippi in the great plains at the base of the Rockies, lived three groups of Algonkins that at one time or another had evidently made their way there from the original eastern home. These were the Blackfeet, Arapaho and Cheyenne.

In historic times the Cheyenne and Arapaho have usually been allies and closely associated. They are to-day on the same reservation. But all the inferences made as to a joint migration of the two tribes from their original eastern home have proved mistaken. The Cheyenne language is closely similar to the dialect of the Ojibway and other tribes of the Great Lake region. The Arapaho is more different —so much so, in fact, that when vocabularies of it were first recorded, its essentially Algonkin character was not recognized. It follows that the Arapaho represent an ancient and the Cheyenne a recent separation from the tribes farther east. The third group in the plains, the Blackfeet, have specialized their dialect to about the same extent as the Arapaho, but in different ways. While they, therefore,



branched off at about the same time as the Arapaho, it is clear that they have been distinct from them ever since.

Conservatism of Indian Languages

It has often been said that the languages of Indians and other uncivilized peoples, in fact all languages that are not fixed by writing, change very rapidly. It has been declared that in the course of a generation or two such idioms alter to an extent that men could not understand the talk of their grandfathers, and that in consequence a very few centuries would suffice to alter the features of a language so thoroughly that its original relationship with kindred languages could no longer be ascertained. All such statements are utterly wild, and there is a mass of evidence to contradict them.

Immediately after the Spanish conquest the Aztec language was

written down. Documents were recorded in it and extensive grammars and dictionaries prepared. These grammars and dictionaries are perfectly correct and entirely applicable to the Aztec language as it is spoken to-day. The same is true of the various Maya dialects of Yucatan. We possess records going back two centuries and more of Eskimo, Algonkin, Iroquois and other languages of the United States and Canada as well as of South American tongues. In no instance is any notable change observable. It may in fact be doubted whether most Indian languages have changed as much in pronunciation in the last three hundred years as English has since the time of Skakespeare.

Of course the vocabularies recorded some centuries ago and those written down recently are often far from identical, but the principal differences of this sort must be laid to the imperfect and often curious systems of orthography used. Almost all Indian languages contain at least some sounds that do not occur in the languages of Europe. The Spanish conqueror or the French explorer would represent these unfamiliar sounds with different letters than the subsequent English settler or German scientist. In fact differences fully as great as those between old and modern vocabularies can be found in lists of words taken down in the same period in recent times, by different observers, particularly if these observers were of different nationality. It is probable that the superstition as regards the alleged rapid change of Indian languages is due largely to this cause.

The conservatism of American languages is brilliantly illustrated by the Athabascan family, another of the great linguistic stocks of North America. All the Athabascan dialects are remarkably close, so that a person acquainted with one could learn to understand another in a very short time. The same grammatical processes continue through all of them with almost no change. Yet some of the Athabascan tribes occupy the interior of Alaska and the northwestern parts of Canada. Two branches are in the great plains: the Sarsee, closely affiliated with the Blackfeet, and the Kiowa-Apache, almost amalgamated with the Kiowa though retaining their own speech. In New Mexico and Arizona are the Navaho and Apache. In the interior of British Columbia, just south of Puget Sound in Washington, along the coast of Oregon, and in northwestern California, are other areas, each separated from the other, in which Athabascan was spoken. The tribes belonging to the family are scattered over parts of an area measured by more than forty degrees of latitude and sixty of longitude and embracing at least half of North America. Their original center of dispersion is unknown, but wherever they came from in the first place it is clear that it must have taken them a very long time to force their way individually over thousands of miles, over mountains and rivers, and constantly crowding aside hostile tribes as they moved from one

residence to a new home. Here again, as in all the historical conclusions which it is possible to draw from linguistic conditions in America, we are dealing with periods measurable at least by thousands of years; and yet in all this long lapse of time the Athabascan dialects have changed but slightly and superficially.

The Eskimo

The Eskimo have often been proclaimed as an Asiatic people. While confined to the shores of Arctic America, their east and west range is tremendous. If one follows the coast, as they must have done in their migrations, the distance between their eastern and western outposts in Greenland and Alaska is at least 5,000 miles. Yet over this whole stretch the language is so uniform that any one dialect is almost entirely intelligible to the people of regions thousands of miles away. The only divergent language belonging to the Eskimo stock is that of the Aleutian Islands. Where the Eskimo came from is still a moot problem, but as there is nothing in Asia to which their language bears any relationship, their Asiatic origin must at best be viewed as doubtful.

How the Languages Sound

Many popular misconceptions are still prevalent as to the nature of Indian languages. It is commonly supposed that they are characterized by strange and harsh sounds such as "clicks" and "gutturals." On examination the so-called clicks turn out to be nothing but a form of l produced more with one side of the tongue than the other and sounding nearly like tl or hl. This sound is perfectly well known in Welsh and in many other languages of the old world. The guttural sounds also are generally not abnormal, and often less conspicuous than in Hebrew and Asiatic languages. As a rule we may state that no native American language possesses any sound formations that can not be exactly paralleled and duplicated in one or more languages of the old world. What is more, it need hardly be said that among a thousand or more languages and dialects there is opportunity for every range of variation, and any attempt to characterize the phonetics of all Indian languages by one term or by a single description must necessarily be fallacious. As a matter of fact there are many forms of native speech that are exceedingly smooth, harmonious and pleasing even to English ears. On the whole the American Indian finds English as full of strange sounds and difficult sound-combinations as we think the Indian languages to be when first we hear them.

Writing of Indian

No American language was written in a native alphabet. So far as the Indians possessed a means of visible communication, it was by pic-

ture writing. In the highest development of this, in Mexico, the picture writing took on to a certain degree, but only partially, a phonetic character. Pictures and symbols were sometimes interpreted as such, and at other times read as sounds, almost exactly as in the rebuses with which we amuse idle moments. Even then, however, the characters usually represented whole words, or at best syllables, and as they did not stand for individual sounds they were never true letters, and did not form an alphabet properly speaking.

All Indian philology accordingly rests on an oral learning of the languages, and all writing of them has had to be in systems applied by the investigator from other languages, or specially devised by him. The former was the earlier and less satisfactory method. The Spaniard used the Roman alphabet with its Spanish values, the Englishman and American the letters of English. Where sounds were encountered which are not present in these languages, they were usually either omitted, or represented by a character whose customary value somewhat resembled the sound in question.

More recent studies have generally been based upon a systematic and scientific modification of the Roman alphabet. In this certain principles have now been universally accepted for half a century. The most important of these are three.

First, every character or letter must represent one and only one sound. Second, each sound, whenever it occurs, must be denoted by one and the same character. Third, single sounds must be written by single letters, and *vice versa,* double letters are used only for combinations of sounds. If these principles are strictly adhered to, it does not much matter what characters or modifications of the Roman letters are employed, as long as the investigator is sufficiently conversant with the language not to confuse those sounds which are somewhat similar; and provided also that he furnishes a key or explanation giving the exact phonetic value of every character employed by him. In the choice of characters there are, however, certain preferences. English k and c, for instance, are usually only two different ways of writing the identical sound. In any scientific system of orthography k is preferable because it has the same value in every European language that uses the Roman alphabet, as well as in Greek and the alphabets derived from it. The letter c, however, stands for a great variety of different sounds. In English and French it represents not only the sound of k, but of s, in Spanish th, in German ts, and in Italian, in certain cases, ch. K, which can not be misunderstood, is therefore always used in scientific systems.

In the same way the five vowel characters are pronounced in almost exactly the same way in the great majority of the languages of Europe. Philology, therefore, uses these letters exclusively with their "continental" values rather than with the English sounds, which are quite

specialized and which sometimes require two letters, like ee or oo, to represent a single sound, and in other cases express a diphthong or double sound, such as a-i, by the single letter i.

In general very few students of American languages employ precisely the same set of modifications of the Roman alphabet, for the reason that the great majority of them are working with different languages, whose sounds are unlike, so that precisely the same set of diacritical marks would be inappropriate and even inaccurate. The foundation of the system is, however, universally accepted, and may be roughly described as consisting of the vowel characters with their continental values, the consonantal characters with their English values, plus diacritical and typographical modifications to meet particular requirements.

Number of Words

There has been particularly great misapprehension as to what may be called the extent or size of Indian languages—the range of their vocabulary. This is not surprising in view of the fact that similar misstatements are still current as to the number of words actually used by single individuals of civilized communities. It is true that no one, not even the most learned and prolific writer, uses all the words of the English language as they are found in an unabridged dictionary. All of us understand a great many words which we habitually encounter in reading and may even hear frequently spoken, but of which our speech faculties for some reason have not made us master. In short, every language, being the property and product of a community, possesses more words than can ever be used by a single individual, the sum total of whose ideas is necessarily much less than those of the whole body. Added to this are a certain mental sluggishness which restricts most of us to a greater or less degree, and the force of habit. Having spoken a certain word a number of times, our brain becomes accustomed to it and we are apt to employ it to the exclusion of its synonyms.

The degree to which all this affects the speech of the normal man has, however, been greatly exaggerated. Because there are, all told, including technical terms, a hundred thousand or more words given in our dictionaries, and because Shakespeare in all his writings used only fifteen thousand different words, and Milton only six thousand, it has been concluded that the average man, whose range of thought and power of expression is immeasurably below that of Shakespeare and Milton, must use an enormously smaller vocabulary. It has been stated that the average English peasant goes through life without ever using more than six or seven hundred words, that the vocabulary of Italian grand opera is only about three hundred words, and that most of us do well if we know a couple of thousand words. If such were the case it would only be natural that the uncivilized Indian, whose life is so

much simpler, and whose knowledge more confined, should be content with an exceedingly small vocabulary.

It is, however, certain that the figures just cited are very erroneous. If any one who considers himself an average person will sit down and make a list or rough estimate of his speaking vocabulary, he will find it to be far above a thousand. It may safely be said that the so-called "average man" knows, and on occasion uses, the names of at least a thousand different things; in other words, that his vocabulary possesses more than a thousand nouns alone. To these must be added the verbs, of which every one employs at least several hundred; adjectives; pronouns; and the other parts of speech, the short and familiar words that are absolutely indispensable to all communication in any language. It may be safely estimated that it is an exceptionally ignorant and stupid person in any civilized country that has not at his command a vocabulary of at least two thousand words, and probably the figure in the normal case is a great deal higher.

When any one has professed to declare on the strength of his observation that a particular Indian language consists of only a few hundred terms, he has displayed chiefly his ignorance. He has either not taken the trouble to exhaust the vocabulary, or has not known how to do so. It is true that the traveler or settler can usually converse with natives to the satisfaction of his own needs with a knowledge of only two or three hundred words. Even the missionary can do a great deal with this stock if it is properly chosen. But of course it does not follow that because the white man in most cases has not learned more of a language, that there is no more. On this point the testimony of the philologist or student, who has made it his business to learn all the language as nearly as may be, is the only evidence that can be considered.

If now we review the Indian languages that have been most thoroughly explored, so to speak, and of which dictionaries are in existence that are even tolerably representative, as of Aztec, Maya, Algonkin, Eskimo, Sioux and several other idioms, it is found that all of these contain 5,000 words, and some considerably exceed this number. What is more, we discover that professions of an *incomplete* knowledge of a language usually come from the very men who have compiled these dictionaries or who have given years to the study of a language. It is the old story that it is only by increased information that one obtains a perception of one's ignorance. The words are there in the Indian languages; it is only when we have learned several thousand that we begin to realize how many there must still be which are unrecorded. It may safely be said that every American Indian language, whether or not it has yet been studied, possessed before coming in contact with white civilization a vocabulary of at least 5,000 different native words.

How the Grammar is Ascertained

Just as the Indian speaks sounds without being able to represent them in writing, and just as he possesses thousands of words without suspecting it, he also follows complex and intricate rules of grammar without being in the least aware of the fact. There is of course nothing strange in this. We are so accustomed to being taught grammar in school that we often allow ourselves to slide into the hasty opinion that we speak and write grammatically on account of this training. There are, however, perfectly illiterate and uneducated people, who, merely through association with those who talk grammatical English, speak with entire correctness. The first grammarians among the Greeks and Hindus did not invent the rules governing speech in their tongues, but only perceived and set down in systematic shape the grammatical forms and constructions already existing in those languages. So it is only a hasty judgment that would conclude that Indian languages are without grammar or form, merely because the Indian does not know that there is such a thing as grammar.

The Indian's ignorance, however, brings it about that the structure of no Indian language can be learned ready made, but has to be gradually explored and worked out step by step. With good interpreters this is a fascinating pursuit, and with proper philological training it is often not as difficult as might at first seem, though it is always a laborious and lengthy task on account of the wealth of the languages and the intricacy of their structure.

For instance, when forms like the following are obtained:

l-emlu-i	I eat
m-emlu-i	you eat
l-emlu-ya	I ate
m-emlu-hi	you will eat
emlu-hi	he will eat

it is obvious on comparing the Indian forms with their English equivalents that the stem *emlu* is the only element that occurs in every one of these Indian words, and the word eat the only one that is common to all the translations. There can, therefore, be no doubt that *emlu* means "to eat." In the same way comparison shows that wherever we have the English pronoun "I," the Indian language in question possesses the prefix *l-*. Similarly "you" is the equivalent of the prefix *m-*, while "he" does not seem to be expressed. A suffix *-i* occurs when the English rendering is in the *present* tense, *-ya* for the *past*, and *-hi* for the English *future*. These five phrases, if we can rely on their having been accurately translated, therefore reveal not only a verb stem, but three pronominal elements and three tense elements. They

show, furthermore, that person in the verb is expressed by prefixes, instead of by independent words, as in English, or by endings, as in Latin; and that tense is denoted by suffixes, as in most other languages. In other words, we have derived from these examples a partial idea of that most difficult element in all grammars, the conjugation of the verb.

It is, however, not always as plain sailing as this. The average Indian, even if he has been an official interpreter, has been accustomed to give only the gist or substance of what he has to translate. He has never been troubled with the finer distinctions of tense, mode, number and case, some of which are quite abstract. He is very apt to slur these distinctions over, and to give an approximate instead of an exact translation; so that it is usually necessary to obtain a great number of examples, and patiently compare them, before any positive deductions can be made with safety. In many tribes even the best interpreter's power of expressing himself accurately in English is quite limited, even though he may understand an ordinary conversation perfectly well. If his own language makes no distinction between singular and plural. as not infrequently happens, he uses the English plural and singular indiscriminately. Many Indian languages lack gender and express "he" and "she" by the same pronoun. Most Indians, unless they have gone to school for some time, fail to observe this distinction, and even the school graduate in his unguarded moments is apt to relapse into the habit of calling a woman "he." When "he," "she," "him," "her," "it," "they" and "them" are all expressed by the one general pronoun "him," the investigator has met a serious difficulty.

His only recourse in such an event is to desist from the attempt to obtain exact translations of individual phrases or detached sentences, and to write down from dictation narratives or other continuous texts of some length, subsequently getting these translated as nearly as may be word for word. Even if the translations are inaccurate in detail, they will be enough to give the drift of the story. Then, by knowing the *context,* the student is often able to correct the faulty expression of his interpreter. By the context he will know whether the pronoun refers to a man or a woman, to one person or several, and whether it is in the subjective or objective case. A single narrative or description may be of but little aid, but when a considerable series has been obtained, and has been carefully analyzed, he has in hand sufficient material to determine almost any point, provided he gives it proper time and consideration. It is for this reason that the collecting of texts in Indian languages has been carried on to so great an extent of recent years, and is justly looked upon as a basis of all analysis of Indian languages that pretends to any thoroughness or completeness.

The Phonograph

Great hopes have often been placed in the phonograph, but except as an indirect accessory, the instrument has proved of no service at all to the student of Indian languages, invaluable though it may be for recording aboriginal music. The phonograph still reproduces sound with too great imperfection. When we hear a record in our own language we do not observe this fact, because we are listening for what we can recognize rather than for those parts of the diction which we fail to recognize. Just as we can understand a person who mutters or whispers or speaks with indistinct articulation, simply because we succeed in hearing the majority of the sounds which he utters, and our imagination and familiarity with the language enable us to supply the missing sounds, until we think we have actually heard the whole—so we do in listening to a speech record from the phonograph. We can follow the whole of a record made in our own language, even if it is mechanically only tolerable; but we can hardly write down correctly a single word of a record made in an entirely foreign language. This may seem strange, but can easily be verified by experiment.

The only value of the phonograph to the student of Indian languages is the indirect one of assisting him in the procuring of texts. The Indian informant has every opportunity to speak as naturally and rapidly as he wishes. When a body of such records has been obtained, they can be gone over sentence by sentence, and if need be, word for word, with an interpreter, who speaks as slowly as may be necessary for correct dictation. By this double method the most satisfactory texts can be obtained. Though the labor is increased, and the instrument serves only for the first step of the process, the final product is a perfect written text.

"Gluing Together"

Many attempts have been made to describe briefly and generally the grammatical structure of Indian languages. It has been commonly said that the languages, as a class, are agglutinating, that they "glue" one element to another to form words. But just such pasting together of word elements into words occurs in many of the Aryan languages, in fact in forms of speech all over the world. It is hard to see why on account of some subsidiary difference the same process should be called "inflection" when it takes place in our own language, and "agglutination" when it occurs in Indian or other idioms. It is probably only a desire to set off ourselves from all other people that is at the bottom of the distinction between "inflecting" and "agglutinating" languages.

Polysynthesis

A different description of American languages is contained in the word "polysynthetic," meaning a high degree of combination. There

is no question but that many Indian languages are extremely polysynthetic, uniting into a single word, especially in connection with the verb stem, many elements of expression which in English and even in Latin and Greek have to be expressed by a number of separate words. Thus the English sentence "I will roll it there with my foot" would be expressed in the Washo language, from which the preceding illustrations have also been drawn, by a *single* word containing eight syllables, and divisible into six distinct elements.

di-liwi- lup- gic- ue- hi
I- foot-with-roll-thither-will

What is particularly characteristic of the polysynthetic process as exemplified by this word, is that most of the elements as used here can not stand as separate words. They are thus more like our prefixes and suffixes and are more properly word-elements than words in themselves. Thus if the Washo wishes to say "I," as in answer to the question "Who is it?," he says *le;* whereas in composition, as in the above long word, "I" is expressed by the prefix *di-*. The word for "foot" is *mayop,* yet the element or prefix meaning "foot" in a polysynthetic compound shows no relation whatever to *mayop,* being *liwi.* In the same way there or thither as a separate word, as in answer to the question "to where?" is *di;* in a compound word the suffix *-ue* is used.

It is necessary to observe that some American languages do not show this peculiar polysynthetic character, but it is true that the majority of them do possess it, and that some carry it to an extreme degree, so that with references to the languages as a class, it can not be denied that they tend to be polysynthetic.

Every variety of grammatical form can, however, be found in the native languages of America, just as they possess a tremendous diversity of words and of phonetic characters. Some of the languages are very simple, others very complex. Some can be readily learned and analyzed, others present great obstacles. In spite of all the work that has been done by ethnologists, missionaries and others, the great majority of languages are still practically unknown. They offer a tempting and almost unlimited field of philological research. Their study is urgent because many have become extinct and most of the remainder are fast perishing before the inroads of English or Spanish; and it is of the utmost importance on account of the aid which it furnishes to history and archeology. Our future knowledge of the history and prehistory of the American Indian will depend more largely on our knowledge of his languages than on any one other thing.

THE PROGRESS OF SCIENCE

CIRCULATING PROFESSORS

HARVARD and Columbia Universities have for several years maintained an exchange of professors with the Prussian government, and both universities have recently made similar arrangements for Paris. Columbia has had at least one visiting professor from Copenhagen, and Wisconsin has recently obtained a Karl Schurz endowment for German professors. Each of our leading universities has lectureships which are frequently filled by foreign men of science and scholars; and there are certain extra university courses, such as the Lowell lectures in Boston and those of the Brooklyn Institute. Thus during the month Professor Svante Arrhenius, of Stockholm, has been giving the Silliman lectures at Yale University; Professor L. T. Hobhouse, of London, lectures at Columbia, and Sir John Murray, of Edinburgh, a course of Lowell lectures. Our students and teachers have for years gone abroad in swarms; foreign students are beginning to frequent our universities, and foreign men of science, scholars and publicists to visit our institutions. Several international congresses have been held in this country and others will follow in due course.

All this exchange of men and ideas has been stimulating and fruitful. Up to the present we have on the whole played the part of the provinces, paying men to come to us and paying for the privilege of visiting them. We have in the main been content to exchange our money for their ideas. With other American republics and with Japan and China conditions have been reversed. With the older European nations they are changing; collectively they still overshadow the United States, but we can compare our institutions and our culture with those of Germany, France or Great Britain on tolerably equal terms.

The official exchange of professors with Berlin has probably been the least successful part of this movement. The visiting professors learn, but their teaching is not particularly profitable. Books and journals are better ways to communicate to one country the scientific work of another, and the foreign language is a bar to oral teaching. A German professor lecturing in his own language for a week in each of twenty American universities would perform a more useful service than in attempting to give regular class-room instruction in one of them. Incidentally it may be noted that attendance at court functions or failure to attend them seems not to cultivate the sense of humor of the American professor.

The eastern seaboard plays somewhat the same part toward the western and southern sections as Europe does to the United States. Students from other parts of the country frequent the eastern universities and their professors lecture elsewhere. But the first official arrangement for an exchange of professors among American institutions has just been announced by Harvard University. A professor is to be sent annually to four colleges in the middle west—Colorado, Grinnell, Knox and Beloit—spending an eighth of a year at each, and the college sends one of its junior officers to Harvard, where he takes part in the regular instruction and may at the same time pursue graduate studies. The scheme is doubtless intended to draw students to Harvard and in a sense usurps the functions of the state university. But it appears to be on the whole commendable. It is certainly desirable for the officers of

the smaller and more remote institutions to retain or form associations with the work of the large universities. The professor from the large university may also gain by first-hand knowledge of educational conditions elsewhere. There is, however, a risk that we may by such means cultivate the traits of the propagandist and exploiter rather than those of the scholar. This is the danger to which the American professor is exposed and from which he has not escaped.

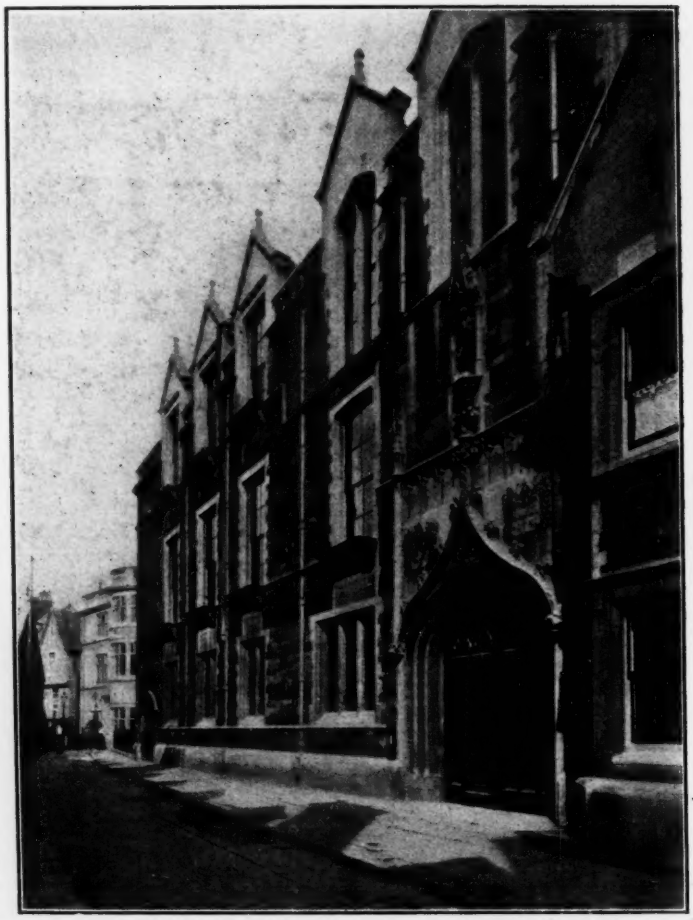
We may hope that the Harvard plan is the initiation of a larger movement which would be wholly beneficial. The colleges of each state should be allied with the state universities or with the private corporations standing in its place. There should be a free exchange of professors and students between all parts of the country. Then there should be a great national university at Washington or elsewhere frequented by advanced students and professors from all parts of the country and all parts of the world—men who would gladly learn and gladly teach. Harvard, Columbia and Chicago, Michigan, Wisconsin and Illinois may be secondary centers, but they should cooperate to establish a superuniversity, which would have the same relation to existing universities that these should hold to the colleges.

THE CAVENDISH LABORATORY OF CAMBRIDGE UNIVERSITY

CERTAIN centers of research and scholarship are national and international in character. It seems that there would be advantages in greater division of labor, so that one subject or group of subjects would be especially favored at each university. To a certain extent this happens under existing conditions, for a department which is strong is likely to become stronger, while a weak department does not readily improve. But there are usually several universities having departments of about equal strength in a given subject and graduate students find the leading men widely scattered. A large group of students and teachers working in the same field exerts an enormous influence.

A real world center of this character is the mathematical and physical work of Cambridge University, maintained since the time of Newton. The Cavendish Laboratory for experimental physics, established forty years ago, has had in its directors three men of remarkable distinction, Clerk-Maxwell, Lord Rayleigh and Sir J. J. Thomson having in succession filled the Cavendish professorship. At the end of 1909 Sir J. J. Thomson had completed twenty-five years of service and to commemorate a tenure of office so full of achievement his colleagues have prepared a volume giving a history of the Cavendish Laboratory, from which we borrow the facts and the pictures of this note. The book contains a series of chapters in which the Clerk-Maxwell period is reviewed by Professor Schuster, the Rayleigh period by Mr. Glazebrook, and the tenure of Professor Thomson by himself and a number of the former students of his laboratory, including Professor Rutherford. There is given a list of memoirs, containing an account of work done in this laboratory and a list of those who have carried out researches in it. They number more than two hundred, including distinguished investigators in all parts of the world.

The practical teaching of physics and laboratories equipped for research are of comparatively recent origin. At Paris, Oxford and London there were but modest beginnings, when the Duke of Devonshire, then chancellor of the University of Cambridge, gave about $40,000 for the erection of the Cavendish Laboratory completed in 1874. It was enlarged at a cost of $20,000 in 1896, and again in 1908, mainly through the gift of Lord Rayleigh of the greater part of the Nobel prize for physics awarded to him in 1904. According to American standards the investment in the building is modest, but



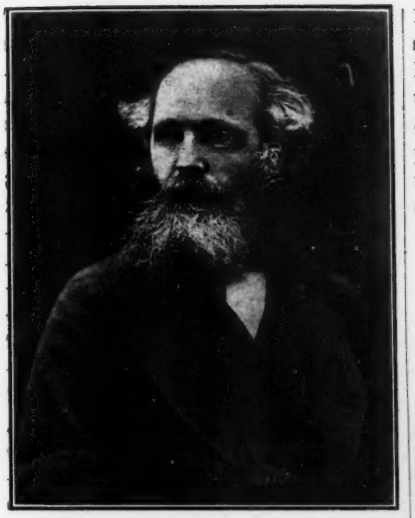
ENTRANCE OF CAVENDISH LABORATORY, SHOWING EXTENSION IN THE DISTANCE.

not so the accomplishment of the men who have directed it and worked in it.

J. Clerk-Maxwell was Cavendish professor of experimental physics from 1871 until his untimely death in 1879. Professor Fleming writes that one of his great courses of lectures on electrodynamics was attended by only one other student, but Hicks, Schuster, Chrystal, Poynting and Glazebrook were among those who worked in the laboratory. Maxwell's investigations on electricity, magnetism and light were in the main theoretical, and their epoch-making importance was fully recognized only after his death; but he exerted great influence on teaching and research in experimental physics.

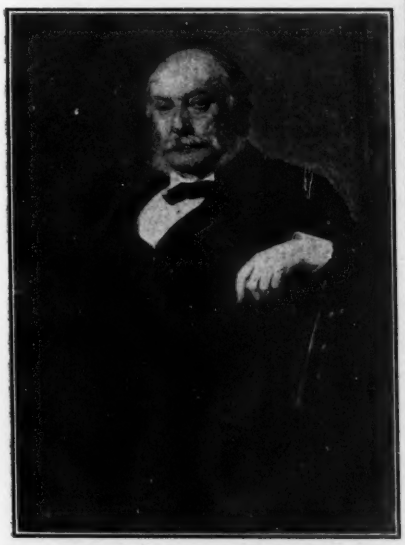
Lord Rayleigh succeeded Clerk-Maxwell in 1879 and retained the chair until 1884, when he retired to his private Terling Place estate and laboratory. During the period of his professorship he completed his exact measurements of electrical units and other researches of fundamental importance. Regular courses for students were established and women were admitted to the laboratory.

J. J. Thomson, then in his twenty-seventh year, was elected to succeed Lord Rayleigh. He had come to Cam-



JAMES CLERK-MAXWELL.

bridge from Owens College and was second wrangler in the mathematical tripos of 1880. Thereafter he began in the Cavendish Laboratory his experimental and mathematical researches, publishing on the electric and magnetic effects produced by the radiation of electrified bodies in 1881 and on the theory of electric discharge in gases in 1883. Thomson was prepared to assimilate the discoveries of Lenard, Röntgen and Becquerel, and has made the Cavendish Laboratory under his direction the great center for the newer physics and the discoveries of the nature of radiation, electricity and the constitution of matter.



LORD RAYLEIGH.
From a painting by Sir George Reid.

SCIENTIFIC ITEMS

WE record with regret the deaths of Dr. Henry Pickering Bowditch, professor of physiology at the Harvard

SIR J. J. THOMSON
From a painting by Arthur Hacker.

Medical School for thirty-five years; of Dr. Samuel Franklin Emmons, of the U. S. Geological Survey, eminent for his contributions to the scientific study of ore deposits, and of Mrs. Ellen Henrietta Swallow Richards, instructor in sanitary engineering in the Massachusetts Institute of Technology.

DR. THEOBALD SMITH, professor of comparative pathology in Harvard University, has been appointed visiting professor at the University of Berlin,

for the second half of the academic year 1911–12.—Dr. Edna Carter, instructor in physics at Vassar College, has been awarded the Sarah Berliner research fellowship for women. She will continue her work in physics at Cambridge under Professor J. J. Thomson, and in the laboratory of Professor Wein, of Würzburg, where she received her doctorate.

Dr. C. G. Abbot, director of the Astrophysical Observatory of the Smithsonian Institution, will this summer conduct an expedition to southern Mexico to make measurements of the sun's radiation, which will be compared with simultaneous observations on Mt. Wilson. The congress has made a special appropriation of $5,000 for this work.

The subscription to the memorial to President Grover Cleveland exceeded $100,000 on the seventy-fourth anniversary of his birth. It will be remembered that the memorial is to be a tower forming part of the graduate college of Princeton University.—Mr. James A. Patten has added $50,000 to the $200,000 which he had given to the Northwestern Medical School for the study of tuberculosis.

In the New York senate on March 21 a bill was introduced to incorporate "The Carnegie Corporation of New York." The incorporators named in the bill are Andrew Carnegie, Senator Elihu Root, president of the Carnegie Endowment for International Peace; Dr. Henry S. Pritchett, president of the Carnegie Foundation for the Advancement of Teaching; William H. Frew, president of the board of trustees of the Carnegie Institute of Pittsburgh; Robert S. Woodward, president of the Carnegie Institution of Washington; Charles L. Taylor, president of the Carnegie Hero Fund Commission; Robert A. Franks, president of the Home Trust Company, and James Bertram, Mr. Carnegie's secretary. Under the language of the bill the incorporators are authorized "to receive and maintain a fund and apply the income to promote the advancement and diffusion of knowledge among the people of the United States, by aiding technical schools, institutions of higher learning, libraries, scientific research, hero funds, useful publications, and by such other agencies and means as shall from time to time be found appropriate."